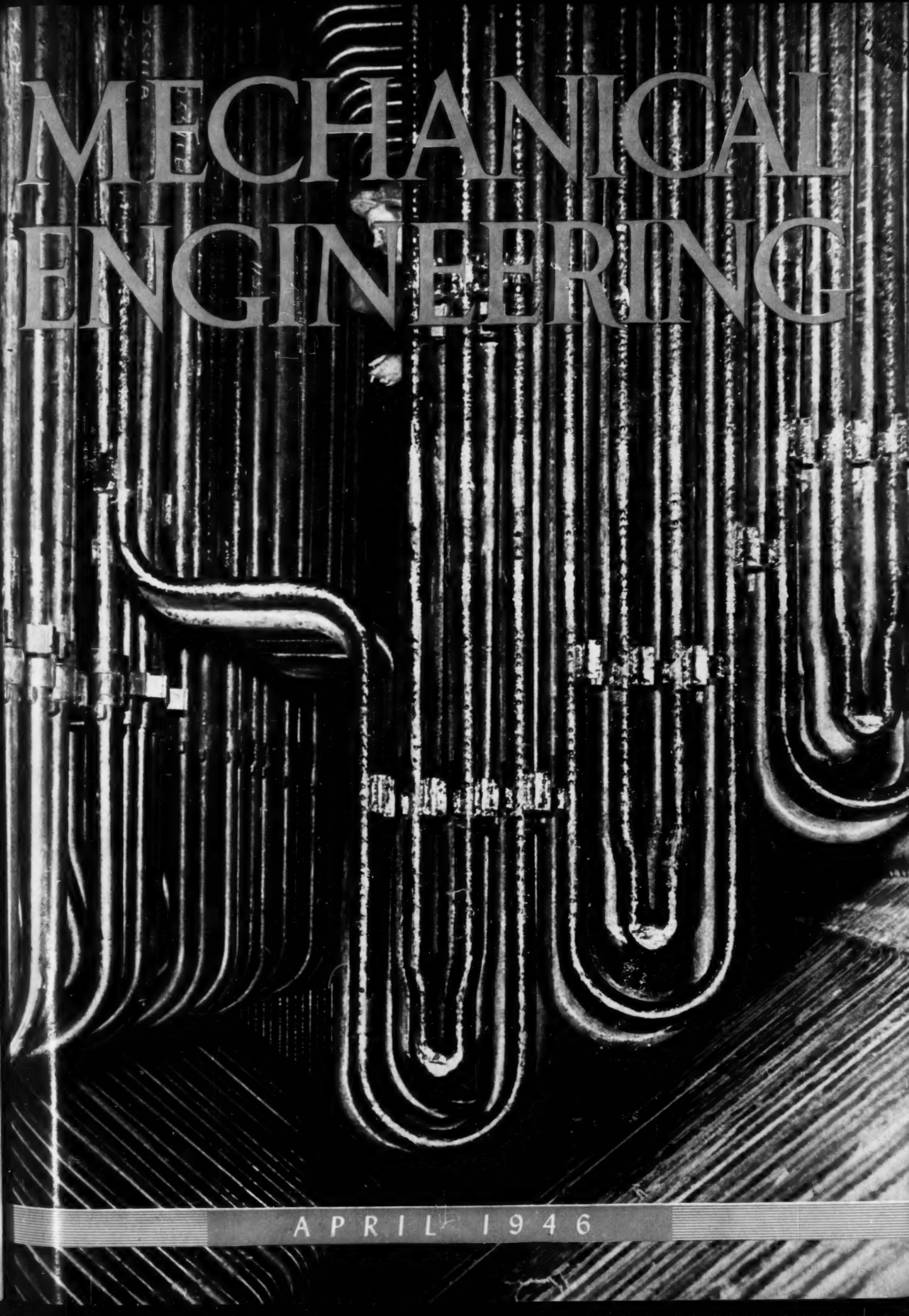
MECHANICAL ENGINEERING

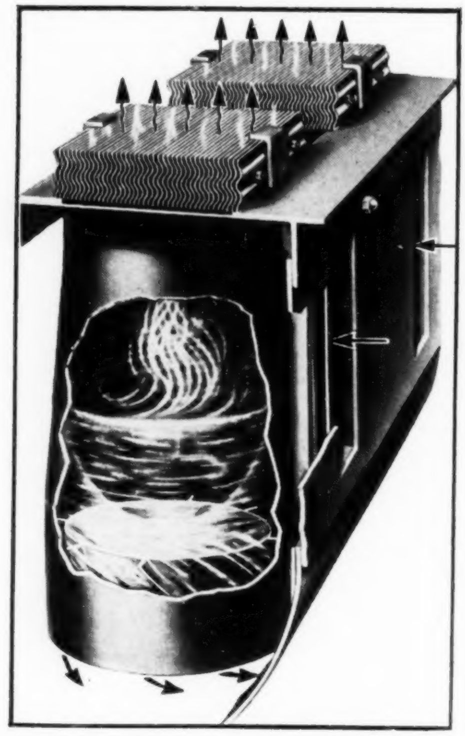


APRIL 1946

cleaner, drier steam

from a cyclone . . .

Elimination of solids and moisture from steam leaving boiler drums, and an assurance of positive boiler water circulation, are accomplished with an unusual degree of effectiveness by the B&W Cyclone Steam Separator. Seven years of wide use in Babcock & Wilcox boilers have thoroughly proved the efficiency of the B&W Cyclone Steam Separator for the consistent and reliable production of clean, dry steam.

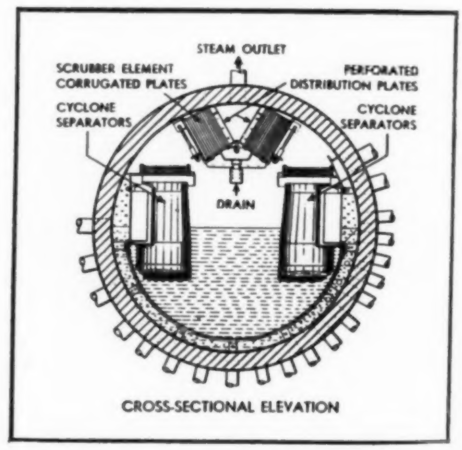


B&W Cyclone Steam Separator with section cut away to show functioning.

WHAT THE CYCLONE DOES:

The separation of the water and its attendant solids from the steam is so nearly complete in the Cyclone Steam Separator that boiler and turbine performance are improved in many important ways:

1. Boilers can be operated at greater water-level variation without priming, making larger and more rapid load swings safely possible.
2. Complete separation of the steam from the water produces a maximum circulating head and delivers solid (steam free) water to the downcomers, thereby protecting boiler tubes against overheating and burnout.
3. Dry steam is assured over wider range in boiler water concentration.
4. Superheater tubes are protected from burnouts and failure due to scale deposits.
5. Longer periods of continuous boiler operation are secured.
6. Savings in maintenance time and expense are effected in boilers and turbines.
7. Safety is promoted by reducing variations between water levels in drum and gauge glass.
8. Turbine blades stay clean longer, permitting longer operating periods between cleanings.
9. Desired KW output can be maintained for longer periods.



Cross section of typical Cyclone Steam Separator installation in a large boiler drum.

The Cyclone Steam Separator is another B&W "first" in the development of better steam-generating equipment—another reason why it pays to *see B&W first* for the latest solution to any steam problem.

Water-Tube Boilers, for Stationary Power Plants, for Marine Service . . . Water-Cooled Furnaces . . . Superheaters . . . Economizers . . . Air Heaters . . . Pulverized-Coal Equipment . . . Chain-Grate Stokers . . . Oil, Gas and Multifuel Burners . . . Seamless and Welded Tubes and Pipe . . . Refractories . . . Process Equipment.

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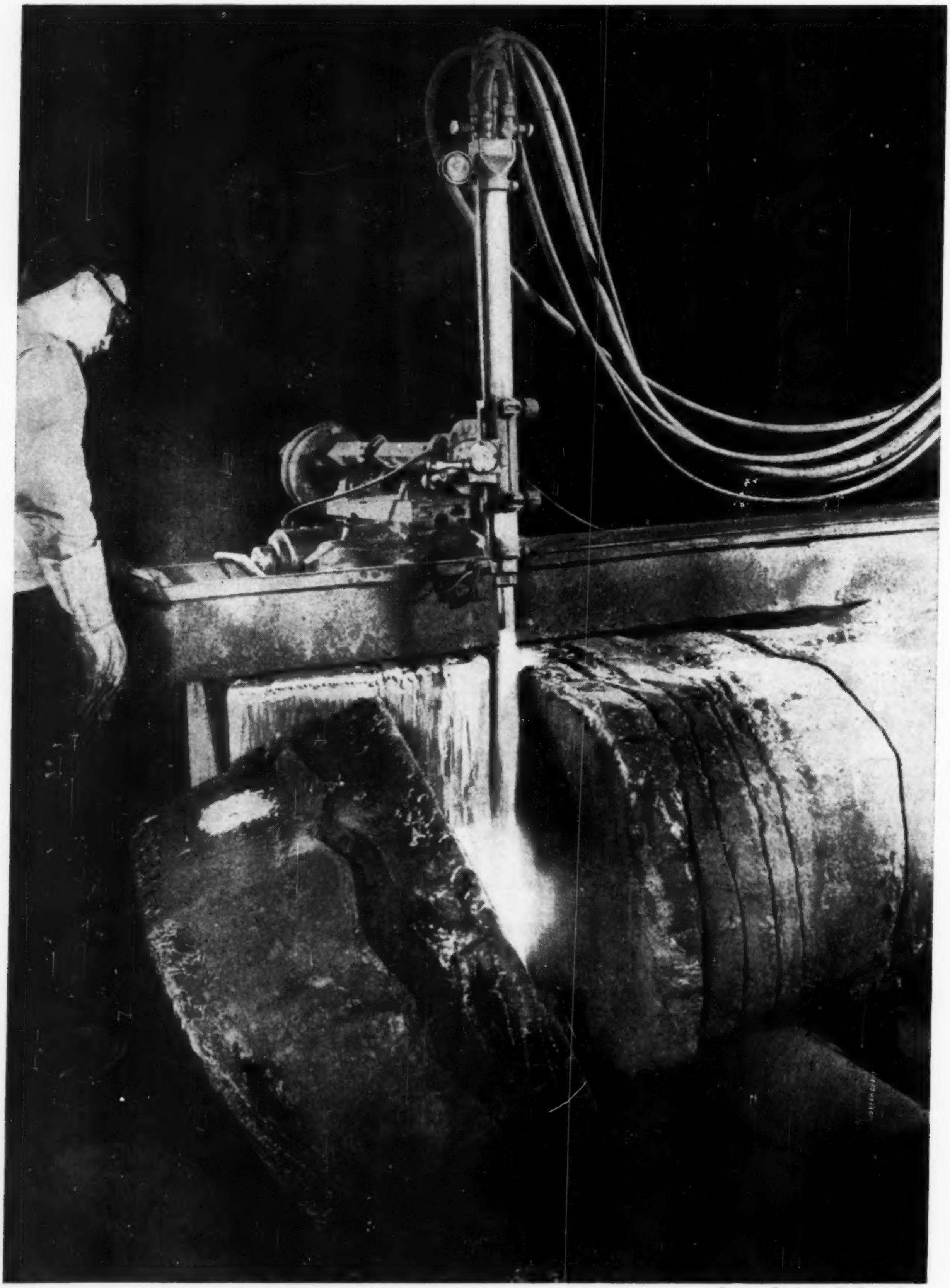

Courtesy Linde Air Products, Co.

New Heavy-Duty Machine-Cutting Blowpipe

(Shown cutting a chrome-nickel-molybdenum hot top to charging-box size. The cut through a 29-in. thick section is made at 3 in. per min.)

Volume 68
No. 4

MECHANICAL ENGINEERING

April
1946

GEORGE A. STETSON, *Editor*

Nuclear Energy

A FEW months ago notice was taken in these pages of what appeared to be an attempt to embroil scientists and engineers in a senseless controversy over the contributions the former made during the war in fields that are normally considered to be the province of the latter. Because of extraordinary conditions brought about by the war, conspicuous instances can be cited in which physicists were forced to perform developmental work. Such instances were seized upon by some persons as evidence that engineers had failed to perform their true functions and hence the physicists had been forced to jump into the breach to save the nation. This contention will not stand analysis. One might as well claim that because a chemist discovered that his cook was not available and he himself undertook to prepare his own meal, the task had become too difficult for cooks and had to be taken over by chemists. No one will deny that a chemist may turn out an appetizing meal, but a chemist does not advance the progress of science when he is boiling an egg or basting a roast instead of working in his laboratory. So it is with scientists and engineers. There is glory enough for both; and if the fact that physicists have done engineering work or engineers have been forced into pure research proves anything, it proves competence in diverse lines and adaptability to compelling circumstances.

Production of nuclear energy on a vast scale has focused public attention on the work of scientists and has brought to scientists highly deserved recognition. But only the badly informed believe that these spectacular achievements were brought about by scientists alone. The task was so huge and so difficult that one wonders at times if anyone could be found who was not involved in it in one way or another.

What one group of engineers contributed to this project is set forth in an article published in this issue which makes clear some of the engineering problems that were involved and the difference between the functions of the scientist and the engineer in carrying it forward to success. As the author, A. C. Klein, says: "Scientists developed the principles of separating isotopes and discovered the phenomenon of uranium 235 fission through observing the action of submicroscopic quantities of uranium. The engineers multiplied their experiments a billionfold, produced the atomic bomb, and opened the door to the era of atomic power."

No engineer can read Mr. Klein's article without experiencing a feeling of pride in his profession and of profound respect for the engineers who toiled so arduously and so intelligently in a pioneering project the like of which the world has never seen developed in so short a space of time. Engineers, like the scientists, are vastly more interested in the future peacetime applications of the developmental work carried on to produce the atomic bomb than they are in its use in a weapon of war of unprecedented destructiveness. Already the engineering uses of nuclear energy are being discussed and groups of engineers are being organized to study the subject. One such group is the A.S.M.E. Committee on Nuclear Energy Application whose personnel is announced on page 374 of this issue.

National Science Foundation

AT the 1945 A.S.M.E. Annual Meeting, which was reported in the January issue of Mechanical Engineering, the attention of the Council was directed to several bills then before the Congress which proposed the setting up of a National Science Foundation. Hearings on these bills were then in progress, and the points of view of a group of 15 engineers on the merits of these bills were reported by A. G. Christie, a member of that group. Sentiment of the Council appeared to be in favor of the Magnuson bill and opposed to the Kilgore bill, and the Sections of the Society were informed of the reasons for this preference. Since November a compromise bill has been introduced, known as the Kilgore-Magnuson bill, S.1850. In the drafting of this bill an attempt has been made to eliminate some of the features of the original Kilgore bill to which scientists and engineers had registered their protests. This compromise bill merits careful study by engineers, for the provisions of such legislation will affect their work for generations.

Ever since the Congress has taken an interest in setting up some form of a National Science Foundation, the American Association for the Advancement of Science has followed the progress of all bills introduced in the Congress relating to such a foundation and has kept the public informed as to their distinctive features as well as developments relating to these bills in the Congress and in public hearings. In the March 1, 1946, issue of *Science* Dr. Meyerhoff, executive secretary, A.A.A.S., in anticipation of probable discussion, at the St. Louis meeting of the Association to be held this spring, on current developments in the Congress relating to the establishment of a National Science Foundation, presented a summary of the history of such legislation with which he included

a brief summary of the current Kilgore-Magnuson bill, S.1850.

There seemed to be no better way to inform readers of MECHANICAL ENGINEERING of these important developments than to reprint Dr. Meyerhoff's article, and this will be found on pages 358–359 of this issue. Readers who wish to study the actual wording of the bill should secure a copy of it from the Government Printing Office, in a document referred to in connection with Dr. Meyerhoff's article.

Engineers and scientists have a decided stake in the National Science Foundation and should familiarize themselves with the provisions of the bill S. 1850. Dr. Meyerhoff's summary and analysis of its origins provides a convenient starting point for such a study.

New England's Machines

SINCE the end of the war the problems of labor relations in industry have greatly overshadowed in the minds of the public the problems and achievements of engineers who are responsible for the material progress of our industrial civilization. In the confused atmosphere of labor relations where values are difficult to assess because they are complex and not subject to precise measurement, it is satisfying to reflect on the achievements of creative minds during the past century and to review developments to which they contributed. Seen in the light of history, the false starts, the difficulties that had to be surmounted, and the failures are overshadowed by the successes, and the continuity of evolutionary development becomes clear in perspective. One such continuity of development is to be found in the machine-tool industry which was reviewed in a recent Newcomen address by Frederick S. Blackall, Jr., member A.S.M.E., and president of the Taft-Peirce Manufacturing Company.

Mr. Blackall limited his review to developments which took place in New England, which, he said, had been "in very truth the cradle of this industry." Although he paid appropriate tribute to developments in machine tools which took place in England and on the Continent, Mr. Blackall showed that the invention of the modern lathe, generally credited to Sir Henry Maudslay, "with which he was able to cut the first precision screw threads on a production basis, largely through his creation of the cross slide in combination with the lead screw and back gears," was originated independently in this country. Maudslay's first machine appeared in about 1800, "but as early as 1791 Sylvanus Brown, of Pawtucket, R. I., had produced a similar invention, and in 1798 David Wilkinson of Pawtucket was granted a patent for a lathe similarly equipped, which he used for commercial job turning work."

Less controversy is likely to rage over Whitney's initiation of the basic concepts of interchangeable-parts production and his invention of the jig and fixture and the development of limit gages, which are the essential elements of mass production as we know it today. It took Whitney many years to bring his system of manufacture to the point where he was able to complete the firearms contract he had entered into with the Secretary of War. "It is to the credit of our government," said Mr. Blackall, "that this project, at which leading European ordnance officers and many of Whitney's compatriots scoffed, was supported through substantial advances of money and the unwavering faith of the Secretary of War." This development took place during the opening years of the 19th century. To quote Mr. Blackall: "Thus was born the interchangeable system of mass production, the touchstone which converted the age-old craft system into a modern industrial economy, brought to the common man conveniences and a standard of living which even kings had not before enjoyed, and launched a wave of creative invention and production such as the world had never known. It was purely an American invention. While across the water, Bentham and Brunel were applying some of the principles of repetitive production and precision to the manufacture of pulley blocks, they had missed the vital element of limit gages, and Europe was to wait half a century before finally adopting the American system, as they themselves called it, first in equipping the Enfield Armory in 1855 with machine tools, jigs, fixtures, and gages, imported from the United States."

If New England had made no other contribution to our industrial civilization than this one alone, it would be glory enough, but, as Mr. Blackall shows and as the nation knows, there were others besides Whitney who made important developments in the machine-tool field. From the shops of these pioneers came the ingenious mechanics who spread out over New England and the nation, each making his own contribution and each giving opportunity for the training of other generations to carry on and amplify their work. "The sons and grandsons of the New England machine-tool pioneers still carry on in many a shop the fine traditions of an earlier day," asserted Mr. Blackall, "for toolbuilding remains, as it always has been, a business in which family influence and family tradition are strong."

Throughout two world wars the extraordinary ability and capacity of this nation to produce in quantity and with high precision for the needs of war have been powerful factors in the victories that have been won. They also provide the backbone of our industrial economy and the means by which the fruits of these victories can be transformed into higher material standards of living. To see many of our great industries temporarily inoperative because of labor disputes is to realize that there are other problems than the technological and engineering ones that must be solved before the full benefits of this industrial economy can be enjoyed. While we review the glorious past in which were developed the means by which high production can be attained, we must give thought to other phases of the industrial economy where men as workers, rather than machines, are involved. When our success in the field of human relations reaches the high level of our success in machine design and production we shall have made another great advance along the roadway of industrial civilization on which Eli Whitney set our feet.

ATOMIC-BOMB ENGINEERING

By A. C. KLEIN

ENGINEERING MANAGER, STONE & WEBSTER ENGINEERING CORPORATION, BOSTON, MASS. FELLOW A.S.M.E.

THE construction of the atomic-bomb plants during the war was an engineering triumph of the first magnitude, as well as a construction achievement unparalleled in the history of that industry. In making this statement, it is without intent to detract from the work of the scientists. Their efforts deserve all of the acclaim they have received by the public, press, and governmental agencies, but magnificent as their accomplishments have been, they are no greater than those of the engineers.

Neither deserves the full credit for the atomic bomb. The work of neither was subordinate to the work of the other; rather, their efforts were complementary. In this project the relative services of the scientists and engineers were no different than they are in many other fields. The scientist, dealing in research, discovers all sorts of facts about the world around us and the universe beyond. Frequently, these discoveries lie dormant for years, decades or even centuries. Sooner or later the engineer takes them up and puts them to practical use, thereby furnishing society with improvements to make life more comfortable and easier. Incidentally, the engineer's work causes these discoveries to yield monetary returns which in turn furnish the funds to the scientists for financing additional research.

The scientist discovered that 2 and 2 make 4; the engineer invented the adding machine. The scientist discovered helium in the sun's corona; engineers separated it from natural gas for military, medical, and commercial use. Scientists developed the principles for separating isotopes and discovered the phenomenon of uranium 235 fission through observing the action of submicroscopic quantities of uranium. The engineers multiplied their experiments a billionfold, produced the atomic bomb, and opened the door to the era of atomic power.

In the atomic-bomb project much of the work of the engineers was carried on at the same time as that of the scientists, rather than sequentially as is usually the case. This made engineering progress more difficult, as the time schedule set up for construction frequently required decisions before the scientists were ready to make them. In such cases, the engineers had to rely on their judgment and experience to adopt measures or to take steps which could be modified if necessary after all the scientific data had been obtained and analyzed. I am reminded of a meeting in which one of the plant operators contended that construction had been started too early and that a better plant could have been built had more time been devoted to completing research work. The reply to this was that the plant was operating and producing material, whereas the foundations would not have been started at that time had we waited for the completion of the scientists' work.

How well the engineers toiled is now well known to the world How well they will be able to continue their work toward the complete development of atomic-power sources will depend upon the zeal and optimism with which they continue and upon the co-operative encouragement which they receive from the governmental authorities to whom Congress entrusts the future of the atomic-power program.

Presented at a meeting of the Boston Section, Boston, Mass., Nov. 20, 1945, of The American Society of Mechanical Engineers.

ELEMENTS OF THE "MANHATTAN DISTRICT" PROGRAM

The atomic-bomb program may be divided into the following principal parts:

1 Research and scientific development.

2 Design and construction of three major plants utilizing, respectively, the diffusion process, the electromagnetic process, and the plutonium process.

3 The operation of these plants to produce fission materials.

4 Development of a bomb to explode these fission materials.

5 Accessory developments, including the townsite construction, the development of the raw-material program, and the construction of heavy-water plants.

The story of the magnificent research program in which every prominent physicist in the United States was engaged is so well known through press releases that it need not be repeated.

The contribution of Boston engineers to the design and construction of production plants was concentrated principally on the plant in which isotope 235 is separated from uranium by the electromagnetic or mass spectroscope method. In principle, this method is very simple. A suitable compound of uranium is first vaporized, then it is ionized or electrified by passage through an electric arc. Next, electrified atoms are given a forward acceleration by passing through electric fields having an increase in potential. Following this, the atoms enter a strong magnetic field which curves the electrified atoms in a circular path. The influence of the magnetic field is to bend the mass 235 atoms into a circle of slightly smaller radius than those of mass 238. At the end of the circle separate containers are provided for the 235 atoms and for the 238 ones.

DESIGN AND CONSTRUCTION OF ELECTROMAGNETIC PLANT

The design and construction of the electromagnetic plant was under the direction of the author's firm. Engineering began in July, 1942, and construction started in February, 1943. Preliminary operation began in November, 1943, and the first section of the plant was turned over to the operators in January, 1944. While the first section of the plant was under construction, process development work was proceeding so successfully that in September, 1943, the design and construction of an extension for an output of several times that of the original plant was approved. Units of this plant were completed and turned over to the operators beginning in May, 1944.

By June, 1942, a group of engineers from the author's firm had selected the plot of land, part of which is now the site for the huge electromagnetic and diffusion plants, and part of which has been converted into the fifth largest city in the State of Tennessee, the community of Oak Ridge, having a population of about 75,000.

Engineering work was carried on in Boston and by a group of engineers who took up residence in Berkeley, Calif., so as to coordinate the work closely with the University of California physicists, who were responsible for the research phase of the project.

For a period of about 6 months another group of engineers, who were resident at the University of Chicago, also worked actively on the basic designs of the plutonium process. They assisted the metallurgical laboratory in the erection of the ex-

perimental plant on the university campus. In that plant the chain-reaction process was first demonstrated. They also selected a site in the Argonne Forest just west of Chicago for a plutonium pilot plant and designed and erected the pilot-plant structures. In December, 1942, the plutonium project was assigned to others.

Engineers from the author's firm also rendered invaluable service in the operation of the electromagnetic plant. Prior to operation, extensive tests were required to demonstrate the operability of each part of the unit. For this purpose a group of engineers who had been prominent in the plant design was sent to Oak Ridge to place the plant in preliminary operation and to assist in ironing out many difficulties which were encountered throughout the operating period. Too much credit cannot be given these men for their skill and vision in handling the many seemingly insurmountable obstacles which arose during the early operating days. Their guiding philosophy, that such obstacles had to be attacked and overcome without regard for working hours or for their own physical welfare, was a most important factor in placing the plants in early operation. They thereby accelerated the time at which the first bomb could be dropped.

After the electromagnetic plant was placed in operation and the production of atomic fission material had commenced, it was necessary to develop means of controlling atomic energy and for releasing it as an explosion over the target. This was the bomb development done in New Mexico and to which a great deal of publicity has been given. The early completion of the electromagnetic plant gave the Los Alamos group the first tangible quantities of fission material with which to work out methods of handling and detonating it. By starting production early in 1944, a year earlier than any other plant, the Los Alamos group was enabled to complete the construction of the bombs which ended the war. Failure to have completed the electromagnetic plant early in 1944 would have jeopardized the entire bomb program.

ERECTION OF HEAVY-WATER PLANT

Another phase of the project in which Boston engineers contributed substantially was in the design and construction of the first catalytic heavy-water plant. Heavy water is water in which the hydrogen atom has a weight of 2 instead of its more usual weight of 1. Prior to 1942, small quantities were being separated in a semipilot plant. To provide for the expected large requirements, arrangements were made for a production-scale plant to be constructed at Trail, British Columbia, as large supplies of electrolytic hydrogen existed there. Construction was started in November, 1942, and operation began in May, 1943, about 8 months ahead of the first plant to be erected in the United States.

Engineers of the author's firm also undertook the co-ordination of the raw-material program in the summer of 1942. One notable incident was the placement of an order by telephone for an entire year's production of the Eldorado Mines, just in time to make it possible for the project to obtain full operation of its uranium mines during the winter of 1942–1943. The mines are located on the eastern shores of Great Bear Lake, north of the Arctic Circle and in the wilderness of northern Canada. Access at that time was possible only by a steamship line which could operate only in mid-summer. During our early investigation of the project it was learned at the University of Chicago that a small order for uranium ore had been placed with Eldorado, but that it would be necessary to take immediate steps to obtain the full output of the mines for the coming winter because the last boat which could leave for the trip up the MacKenzie River before ice closed navigation, was then being loaded. No time was lost. A telephone order was placed that day and men and supplies were rushed to the boat by Eldorado, and the full year's ore production gained for the project. Much work was also done in placing orders for the co-ordination of other parts of the raw-material program.

In most instances, companies capable of doing this work had taken small trial orders, and when the requirements were increased to large-scale production their plants were inadequate and had to be substantially increased in capacity. This work was prosecuted vigorously during the summer and fall of 1942, while the Manhattan District was in the formative stage. Toward the end of 1942 the raw-material branch of the Manhattan District took form and in December it took over the responsibility for the procurement of all raw materials.

BUILDING OAK RIDGE

Another activity was the construction of the town of Oak Ridge. This, the fifth largest city in the State of Tennessee, with a population of 75,000, sprang up almost overnight out of the cornfields and farms of Roane and Anderson Counties. The original town layouts, building designs, and townsite construction were made by Stone & Webster. Later, architects were called in to complete the townsite planning and the design of the remaining townsite structures. The author's firm, however, handled the construction of the entire townsite to its completion and continued design work on all utilities, including water supply, sewage disposal, and water and electrical distribution and sewage-collection systems.

DETAILS OF THE ELECTROMAGNETIC PROCESS

While it is not possible to touch on all of the important engineering features of the electromagnetic process, some of them, which may now be divulged, may be of interest.

Vacuum. The beam of electrified uranium atoms, which is curved by the action of the strong magnetic field, must operate in an extremely high vacuum. As much air as possible must be exhausted from the containers, otherwise ionized uranium atoms would collide with atoms of oxygen and nitrogen. In so doing, they might lose their electric charges and then would no longer be subject to the influence of the magnetic field; or else they might be deflected by the collision and would not find their way into the proper collection receptacle.

In steam-turbine practice, 1 in. of mercury, or 25 mm, is considered a high vacuum, but even such a vacuum would contain enough air to prevent any separation of the 235 isotope. The vacuum stipulated for proper separation is of the order of 10^{-6} of a millimeter or 25,000,000 times that which is standard in power-plant practice. To produce such a vacuum, enormous pumps of the diffusion type had to be designed. The engineering group at Berkeley prepared these designs in co-operation with experts of the Radiation Laboratory.

Electrical Conductors of Silver. Another interesting engineering feature was the use of silver instead of copper for electrical conductors. In all, 14,000 tons of silver, having a value of over $400,000,000, were used. It is interesting to note that the value of this silver just about equals all other expenditures for the entire electromagnetic project. The silver was borrowed from the United States Treasury, was delivered in ingots to copper rolling mills, where it was rolled into strips. These were later welded together with silver solder into conductors of the requisite length. The entire operation was under continuous surveillance of Army officers.

Production Magnets. A third engineering feature was the design and construction of the production magnets. These are huge structures 250 ft long, each of which contains thousands of tons of steel of the highest possible permeability. Prior to their construction, the largest magnet in existence was undoubtedly that of the 184-in. cyclotron at Berkeley. We were

required to design and build magnets nearly 100 times as large. One of the problems in connection with the magnet design was that of carrying on operations in the strong magnetic field which surrounded each of the magnets. This magnetic force was so strong that when a tenpenny nail was held in the hand, a strong effort was necessary to prevent the wrist from being twisted. The pull on the nails in the heels of a pair of shoes was strong enough to make walking difficult. An ordinary wrench or a piece of pipe would either be wrested from a workman's hand or if he held onto it, would be drawn against the magnet face and his knuckles skinned. To counteract this, all movable equipment and structures that came within the range of the magnetic field had to be built of nonferrous metals or of nonmagnetic steel. This made it impossible to use standard designs for any of this equipment. Large quantities of stainless and other nonmagnetic steels had to be procured at a time when they were badly needed for other parts of the war program. Workmen in many shops had to be trained in the welding of these materials, in heat-treating and hardening them, and in working with them in many other ways. A complete set of small tools of beryllium copper had to be designed and produced.

Operation and Maintenance Problems. There were other engineering problems introduced by the need of delivering a plant which could operate continuously for 24 hours per day and 365 days per year. These involved the introduction of many provisions which scientists did not have to consider at all. Among these may be mentioned water, air, and oil cooling of various parts of the magnets; development of quick-detachable pipe and electrical connections; development of equipment for quickly detecting leaks even of microscopic size into the vacuum chambers; provision for maintaining coolant solutions at specified dielectric strength, and servicing and repair facilities for the principal operating units involved in the process.

PROCESS OF REDUCING ORE

During the operating period not all of the feed material is separated into its two component isotopes. A considerable proportion of it goes astray and has to be recovered from the interior walls of the containing vessel and from parts of the operating equipment. The energy of the ionized particles is also so great that those which go astray and which impact on various parts of the apparatus combine either chemically or physically with the metals forming those parts. The result is that a large operating area must be provided for washing and cleaning operations, in which all parts of the operating apparatus are cleaned with steam, acid, and in some cases, by an electrostripping process.

The product is an acid solution of uranium compounds containing large quantities of iron, nickel, copper, and a number of other metallic elements. All of these must be separated from the uranium before it can be recycled in the process, or before it can be passed on to the final concentration stage. Also, the uranium must be converted to the chemical compound which has been found most suitable for feed to the process. This compound must be of the highest degree of purity, completely dry, and very finely pulverized. One of the important tasks was to design an enormous chemical plant in which these reclaiming operations are conducted. Almost all of this equipment had to be designed from the ground up, with only test-tube or small pilot-plant experiments as a guide. Here again, the magnification was of the order of a hundredfold or more.

EVERY TRACE OF URANIUM CONSERVED

One of the interesting things about the chemical operations is the precaution which is taken to salvage every possible grain of uranium whose 235 content has been enriched. It is only by such precautions that the plant capacity is kept up to rating. Some of the precautions are interesting. One is the recovery of splashings from the uniforms of operators in the chemical area. In the cleaning process there is inevitably some splash, and drops of uranium solution are absorbed by the operators' clothing. To recover this, the uniforms are washed every day in small laundries in the individual buildings. The wash water is saved and treated for the recovery of its uranium content. When the uniforms are worn out, they are collected and sent to an incinerator building where they are burned and the ashes digested with acid and treated for uranium recovery. Shoes of the operators are similarly treated. They are periodically collected and likewise burned in the incinerators.

In the separation apparatus a large number of carbon parts are provided to protect the metal structures from beam impingement. These become impregnated with uranium atoms which impact on them. They are collected and sent to the incinerator building to be burned in an atmosphere of oxygen. The small amount of ash which results is treated for uranium recovery. Whenever a metal part is replaced, the old part is dissolved in acid which is then treated to recover any traces of uranium. As may be judged, the salvage operations are an extensive and important part of the plant operation. Several large buildings are provided exclusively for the treatment of salvage solutions, and a large incinerator building is provided for burning any combustible material which might contain traces of uranium. Another salvage operation which may seem far-fetched is the treatment of the ventilating air from the chemical areas for any uranium-bearing entrained dust it might otherwise carry from the building into the outside atmosphere.

Another problem of the engineers was to design and construct a plant or factory that could be operated by personnel of average intelligence, none of whom had more than the faintest idea of what his job was all about.

In the research work experienced personnel of the highest caliber were available. When we went to Berkeley the first time, the large cyclotron building was filled with workmen, some engaged in pipe fitting, others making electrical connections, and some doing carpentry. It was most amazing later to have these same men introduced by the title of doctor, and to have them go the the blackboard and give learned discourses on their work. I am reminded of an incident that occurred during one of General Grove's visits to the laboratory after the work was well on its way toward solution, and when the General was riding Professor Lawrence about the common tasks which he believed some of these highly educated physicists were performing. After going through the duties of several men, the General picked on a man who was engaged in reading several meters and in recording their data. "Is it necessary," the General asked, "to have a doctor of philosophy to perform that task?" By this time Lawrence was getting a bit nettled. "No," he said, "a doctor of philosophy is not necessary to perform that job. I imagine that even a West Point graduate could do it." Needless to say, that was the end of that discussion.

However, it does illustrate rather vividly one of the important problems of the engineers. Most of the operations at Clinton were carried on by girls having a grammar-school or only part of a high-school education. Their work was systematized to be within reach of their capabilities by providing automatic control equipment of a complexity never before developed, so that all they had to do to control the operation was to keep watch of a few meters and to operate corresponding dials.

MINIMUM OF EQUIPMENT DEVELOPED

Another engineering difficulty arose from the fact that the time schedule permitted the development of only a minimum

perimental plant on the university campus. In that plant the chain-reaction process was first demonstrated. They also selected a site in the Argonne Forest just west of Chicago for a plutonium pilot plant and designed and erected the pilot-plant structures. In December, 1942, the plutonium project was assigned to others.

Engineers from the author's firm also rendered invaluable service in the operation of the electromagnetic plant. Prior to operation, extensive tests were required to demonstrate the operability of each part of the unit. For this purpose a group of engineers who had been prominent in the plant design was sent to Oak Ridge to place the plant in preliminary operation and to assist in ironing out many difficulties which were encountered throughout the operating period. Too much credit cannot be given these men for their skill and vision in handling the many seemingly insurmountable obstacles which arose during the early operating days. Their guiding philosophy, that such obstacles had to be attacked and overcome without regard for working hours or for their own physical welfare, was a most important factor in placing the plants in early operation. They thereby accelerated the time at which the first bomb could be dropped.

After the electromagnetic plant was placed in operation and the production of atomic fission material had commenced, it was necessary to develop means of controlling atomic energy and for releasing it as an explosion over the target. This was the bomb development done in New Mexico and to which a great deal of publicity has been given. The early completion of the electromagnetic plant gave the Los Alamos group the first tangible quantities of fission material with which to work out methods of handling and detonating it. By starting production early in 1944, a year earlier than any other plant, the Los Alamos group was enabled to complete the construction of the bombs which ended the war. Failure to have completed the electromagnetic plant early in 1944 would have jeopardized the entire bomb program.

ERECTION OF HEAVY-WATER PLANT

Another phase of the project in which Boston engineers contributed substantially was in the design and construction of the first catalytic heavy-water plant. Heavy water is water in which the hydrogen atom has a weight of 2 instead of its more usual weight of 1. Prior to 1942, small quantities were being separated in a semipilot plant. To provide for the expected large requirements, arrangements were made for a production-scale plant to be constructed at Trail, British Columbia, as large supplies of electrolytic hydrogen existed there. Construction was started in November, 1942, and operation began in May, 1943, about 8 months ahead of the first plant to be erected in the United States.

Engineers of the author's firm also undertook the co-ordination of the raw-material program in the summer of 1942. One notable incident was the placement of an order by telephone for an entire year's production of the Eldorado Mines, just in time to make it possible for the project to obtain full operation of its uranium mines during the winter of 1942–1943. The mines are located on the eastern shores of Great Bear Lake, north of the Arctic Circle and in the wilderness of northern Canada. Access at that time was possible only by a steamship line which could operate only in mid-summer. During our early investigation of the project it was learned at the University of Chicago that a small order for uranium ore had been placed with Eldorado, but that it would be necessary to take immediate steps to obtain the full output of the mines for the coming winter because the last boat which could leave for the trip up the MacKenzie River before ice closed navigation, was then being loaded. No time was lost. A telephone order was placed that day and men and supplies were rushed to the boat by Eldorado, and the full year's ore production gained for the project. Much work was also done in placing orders for the co-ordination of other parts of the raw-material program.

In most instances, companies capable of doing this work had taken small trial orders, and when the requirements were increased to large-scale production their plants were inadequate and had to be substantially increased in capacity. This work was prosecuted vigorously during the summer and fall of 1942, while the Manhattan District was in the formative stage. Toward the end of 1942 the raw-material branch of the Manhattan District took form and in December it took over the responsibility for the procurement of all raw materials.

BUILDING OAK RIDGE

Another activity was the construction of the town of Oak Ridge. This, the fifth largest city in the State of Tennessee, with a population of 75,000, sprang up almost overnight out of the cornfields and farms of Roane and Anderson Counties. The original town layouts, building designs, and townsite construction were made by Stone & Webster. Later, architects were called in to complete the townsite planning and the design of the remaining townsite structures. The author's firm, however, handled the construction of the entire townsite to its completion and continued design work on all utilities, including water supply, sewage disposal, and water and electrical distribution and sewage-collection systems.

DETAILS OF THE ELECTROMAGNETIC PROCESS

While it is not possible to touch on all of the important engineering features of the electromagnetic process, some of them, which may now be divulged, may be of interest.

Vacuum. The beam of electrified uranium atoms, which is curved by the action of the strong magnetic field, must operate in an extremely high vacuum. As much air as possible must be exhausted from the containers, otherwise ionized uranium atoms would collide with atoms of oxygen and nitrogen. In so doing, they might lose their electric charges and then would no longer be subject to the influence of the magnetic field; or else they might be deflected by the collision and would not find their way into the proper collection receptacle.

In steam-turbine practice, 1 in. of mercury, or 25 mm, is considered a high vacuum, but even such a vacuum would contain enough air to prevent any separation of the 235 isotope. The vacuum stipulated for proper separation is of the order of 10^{-6} of a millimeter or 25,000,000 times that which is standard in power-plant practice. To produce such a vacuum, enormous pumps of the diffusion type had to be designed. The engineering group at Berkeley prepared these designs in co-operation with experts of the Radiation Laboratory.

Electrical Conductors of Silver. Another interesting engineering feature was the use of silver instead of copper for electrical conductors. In all, 14,000 tons of silver, having a value of over $400,000,000, were used. It is interesting to note that the value of this silver just about equals all other expenditures for the entire electromagnetic project. The silver was borrowed from the United States Treasury, was delivered in ingots to copper rolling mills, where it was rolled into strips. These were later welded together with silver solder into conductors of the requisite length. The entire operation was under continuous surveillance of Army officers.

Production Magnets. A third engineering feature was the design and construction of the production magnets. These are huge structures 250 ft long, each of which contains thousands of tons of steel of the highest possible permeability. Prior to their construction, the largest magnet in existence was undoubtedly that of the 184-in. cyclotron at Berkeley. We were

required to design and build magnets nearly 100 times as large. One of the problems in connection with the magnet design was that of carrying on operations in the strong magnetic field which surrounded each of the magnets. This magnetic force was so strong that when a tenpenny nail was held in the hand, a strong effort was necessary to prevent the wrist from being twisted. The pull on the nails in the heels of a pair of shoes was strong enough to make walking difficult. An ordinary wrench or a piece of pipe would either be wrested from a workman's hand or if he held onto it, would be drawn against the magnet face and his knuckles skinned. To counteract this, all movable equipment and structures that came within the range of the magnetic field had to be built of nonferrous metals or of nonmagnetic steel. This made it impossible to use standard designs for any of this equipment. Large quantities of stainless and other nonmagnetic steels had to be procured at a time when they were badly needed for other parts of the war program. Workmen in many shops had to be trained in the welding of these materials, in heat-treating and hardening them, and in working with them in many other ways. A complete set of small tools of beryllium copper had to be designed and produced.

Operation and Maintenance Problems. There were other engineering problems introduced by the need of delivering a plant which could operate continuously for 24 hours per day and 365 days per year. These involved the introduction of many provisions which scientists did not have to consider at all. Among these may be mentioned water, air, and oil cooling of various parts of the magnets; development of quick-detachable pipe and electrical connections; development of equipment for quickly detecting leaks even of microscopic size into the vacuum chambers; provision for maintaining coolant solutions at specified dielectric strength, and servicing and repair facilities for the principal operating units involved in the process.

PROCESS OF REDUCING ORE

During the operating period not all of the feed material is separated into its two component isotopes. A considerable proportion of it goes astray and has to be recovered from the interior walls of the containing vessel and from parts of the operating equipment. The energy of the ionized particles is also so great that those which go astray and which impact on various parts of the apparatus combine either chemically or physically with the metals forming those parts. The result is that a large operating area must be provided for washing and cleaning operations, in which all parts of the operating apparatus are cleaned with steam, acid, and in some cases, by an electrostripping process.

The product is an acid solution of uranium compounds containing large quantities of iron, nickel, copper, and a number of other metallic elements. All of these must be separated from the uranium before it can be recycled in the process, or before it can be passed on to the final concentration stage. Also, the uranium must be converted to the chemical compound which has been found most suitable for feed to the process. This compound must be of the highest degree of purity, completely dry, and very finely pulverized. One of the important tasks was to design an enormous chemical plant in which these reclaiming operations are conducted. Almost all of this equipment had to be designed from the ground up, with only test-tube or small pilot-plant experiments as a guide. Here again, the magnification was of the order of a hundredfold or more.

EVERY TRACE OF URANIUM CONSERVED

One of the interesting things about the chemical operations is the precaution which is taken to salvage every possible grain of uranium whose 235 content has been enriched. It is only by such precautions that the plant capacity is kept up to rating. Some of the precautions are interesting. One is the recovery of splashings from the uniforms of operators in the chemical area. In the cleaning process there is inevitably some splash, and drops of uranium solution are absorbed by the operators' clothing. To recover this, the uniforms are washed every day in small laundries in the individual buildings. The wash water is saved and treated for the recovery of its uranium content. When the uniforms are worn out, they are collected and sent to an incinerator building where they are burned and the ashes digested with acid and treated for uranium recovery. Shoes of the operators are similarly treated. They are periodically collected and likewise burned in the incinerators.

In the separation apparatus a large number of carbon parts are provided to protect the metal structures from beam impingement. These become impregnated with uranium atoms which impact on them. They are collected and sent to the incinerator building to be burned in an atmosphere of oxygen. The small amount of ash which results is treated for uranium recovery. Whenever a metal part is replaced, the old part is dissolved in acid which is then treated to recover any traces of uranium. As may be judged, the salvage operations are an extensive and important part of the plant operation. Several large buildings are provided exclusively for the treatment of salvage solutions, and a large incinerator building is provided for burning any combustible material which might contain traces of uranium. Another salvage operation which may seem far-fetched is the treatment of the ventilating air from the chemical areas for any uranium-bearing entrained dust it might otherwise carry from the building into the outside atmosphere.

Another problem of the engineers was to design and construct a plant or factory that could be operated by personnel of average intelligence, none of whom had more than the faintest idea of what his job was all about.

In the research work experienced personnel of the highest caliber were available. When we went to Berkeley the first time, the large cyclotron building was filled with workmen, some engaged in pipe fitting, others making electrical connections, and some doing carpentry. It was most amazing later to have these same men introduced by the title of doctor, and to have them go the the blackboard and give learned discourses on their work. I am reminded of an incident that occurred during one of General Grove's visits to the laboratory after the work was well on its way toward solution, and when the General was riding Professor Lawrence about the common tasks which he believed some of these highly educated physicists were performing. After going through the duties of several men, the General picked on a man who was engaged in reading several meters and in recording their data. "Is it necessary," the General asked, "to have a doctor of philosophy to perform that task?" By this time Lawrence was getting a bit nettled. "No," he said, "a doctor of philosophy is not necessary to perform that job. I imagine that even a West Point graduate could do it." Needless to say, that was the end of that discussion.

However, it does illustrate rather vividly one of the important problems of the engineers. Most of the operations at Clinton were carried on by girls having a grammar-school or only part of a high-school education. Their work was systematized to be within reach of their capabilities by providing automatic control equipment of a complexity never before developed, so that all they had to do to control the operation was to keep watch of a few meters and to operate corresponding dials.

MINIMUM OF EQUIPMENT DEVELOPED

Another engineering difficulty arose from the fact that the time schedule permitted the development of only a minimum

amount of equipment. Even that minimum was tremendous. However, especially in the electric-control phase, every effort was made to adapt standard equipment then being turned out on regular production lines. Physicists constantly pointed out that better equipment could be provided and that they could direct its development, but whenever a standard piece of apparatus was available, we insisted on using it rather than stopping to develop something that might do the job slightly better. If it had not been for this guiding principle, the plant could not have been completed in time to aid in the early downfall of Japan.

MEASURES OF SECRECY

Another important engineering handicap was introduced by security regulations. Secrecy was so great that at times it was as though the whole project was shrouded in an impenetrable fog. Of the group of nearly 800 engaged on the work in Boston, less than half a dozen were entrusted with complete information concerning the project and its objective. A few others must have drawn deductions, but even they could not guess the terrific destruction that would result from their work.

As a fundamental secrecy measure, it was necessary for us to set up a complete engineering organization wholly apart from our other work. Only American citizens were permitted to work on the project and then only after their records had been subjected to severe scrutiny by the Intelligence Division of the War Department. Only American citizens were permitted to enter any of the premises and identification either by an authorized engineer or by presentation of a birth certificate was required.

In our engineering and construction groups the word uranium was never mentioned. Its code name was "tube alloy;" 235 and 238 were likewise taboo. These components were first known as magnesium and aluminum, but later it was decided that these were too revealing and thereafter they simply bore the code letters X and Y. Each one of the 10,000 drawings that was prepared for the project was stamped with a restricted stamp and an espionage stamp before a single line was put on them by a draftsman. Special efforts were made either by coding or by omission to keep all revealing words off the drawings. No building was ever spoken of by its name but rather by a code number and today most of the people who worked on the project could not identify any of the buildings by their proper names.

In many cases it became necessary to prepare drawings which contained too much revealing information to permit them to be widely distributed. These drawings were stamped "Confidential" or "Secret" and when they were sent to the job they were deposited in sealed filing cases or vaults to which only a few confidential employees had access. Any further distribution of the information they contained had to be done by piecemeal sketches and notes made within the restricted area. The same secrecy regulations had to be imposed on all manufacturers who developed equipment in any way different from their standard output. Not only were the design divisions of these manufacturers under the strictest secrecy regulations, but those portions of their shops which produced finished or semifinished assemblies were also placed under strict guard, staffed only by confidential employees of unquestioned loyalty and American citizenship.

Burdensome as were these restrictions, they were accepted cheerfully by all those working on the project, particularly by the manufacturers and their sales representatives. The nation owes a debt of gratitude to all those who worked so effectively in the darkness.

In the execution of its contract with the Manhattan District, Stone & Webster Engineering Corporation expended about $400,000,000. Of this amount, $275,000,000 was spent for materials and equipment. This was at the rate of over $2,000,000 per week during the active procurement period.

This tremendous procurement program was made even more difficult because the deliveries required verged on the impossible. Time was so important to the program that the normal procedure of placing business with low bidders was frequently discarded. In many cases, large orders were divided among three or more suppliers in order to get early production from all of their shops. In other instances, the time scheduled for building completion was so short that orders were placed without competitive bidding.

FUTURE OF ATOMIC POWER

In looking toward the future of atomic power we must do so from two viewpoints: (1) Its military aspects; and (2) its industrial potentialities. The military situation may be summed up about as follows:

1 There is an abundant supply of uranium ore in almost every part of the world, and the supply of other raw materials for the production of bomb explosive is equally abundant.

2 Scientific principles underlying the production of bomb material are known or are readily available to any nation desiring to make use of them.

3 The secrets of the detonating mechanism are known to several nations; England and Canada, and possibly to Denmark and France. These nations have also had an opportunity to learn the engineering secrets and production methods that have been tried and found successful in the United States. Therefore, the only thing which would prevent them from producing atomic bombs is their inability to construct and operate production plants.

Those other nations which have not been permitted to learn about our work are handicapped further by the need of working out the necessary designs. From my knowledge of the magnitude of the construction work involved, and of the detailed design work which the construction of a new plant would require, it is my opinion that it would take foreign nations from 5 to 10 years before they could produce an atomic bomb; 5 years for those nations which have had access to the engineering secrets, and 10 years for those which have not. There is a further question whether any of these nations could in fact support an atomic-bomb program from an economic standpoint, or whether they have the industrial organizations capable of doing the work.

The latter is most important. What we have accomplished in the past 3 years under the stress of war was a task that would have required a generation in peacetime. It required the utmost in engineering, fabrication, and construction by the most highly experienced technicians of hundreds of our most important industrial organizations. No other nation could duplicate their performance. It should be the responsibility of the Congress to maintain, unimpaired, this very real advantage that the United States has over any other nation.

As to the future of atomic power, all sorts of prophecies have been made that we are on the threshold of an atomic era in which unlimited quantities of energy will be available at low cost for industrial, commercial, and domestic purposes. A piece of 235 the size of a pea, buried in front of one's doorstep, will heat the house during its entire life; a slightly smaller piece will operate an automobile; airplanes and steamships will be similarly fueled. These are some of the prophecies that have been made.

POWER INSTALLATIONS POSSIBLE

It will probably be several generations before this millennium is reached, and probably no reader of this paper will ever heat a home or run an automobile by atomic power. However, I do

believe that large power installations can be developed even within our lifetime.

The speed with which atomic power can be made available in the United States depends very largely on the attitude which the Government takes toward its development. We have the raw materials, scientific and engineering information, and the industrial organization to produce atomic material, to improve the present processes, or to develop new processes for its production. We also have the facilities and ability to develop apparatus to convert that material into energy.

At the moment our Government has placed all of the engineers who have any knowledge or experience with atomic energy under a strict bond of secrecy. The Government also controls every phase of the process through thousands of patents covering every part of each of the processes. This knowledge and the right to use these patents must be turned over to industry before any progress can be made toward the atomic age. I suggest that large manufacturing companies be licensed to use these patents and that they be protected in the use of any additional patentable discoveries which they may make. Congress should also include in its appropriations sizable amounts for engineering development work so that it can parallel new scientific discoveries. This is important not only from an industrial but also from a military standpoint. Appropriations should also be made for the continued operation and development of the three plants which are now in operation.

FUTURE OF ATOMIC-PLANT OPERATION

After a stock pile of atomic material has been accumulated, there will be a wave of economy urged on Congress to shut the plants down. I believe that their operations can be cut to a minimum; possibly one building or one train of equipment can be continued in commercial operation even before our stock pile has reached the necessary size. The rest of these plants should be shut down but kept in readiness to resume operation on short notice.

Over a period of several years this program would result in substantial reductions in the cost of producing atomic material. Capacities will also be increased. This will further reduce costs by slashing fixed charges. There will come a time when the economies resulting from the continued plant operation and from the adaptation of new research discoveries will result in atomic power attaining a parity with power obtained from fuel. One pound of uranium 235 or plutonium will develop as much heat as 1500 tons of coal. At $6 per ton, this establishes a cost of $9000 per lb for the 235, and this figure must be attained before the atom, as a power source, will be competitive with coal.

We are still a long way from attaining that goal. When we do attain it, it does not mean that all of our steam-generating plants will be scrapped or become obsolete. Electricity is still the form in which energy will be distributed for domestic and industrial purposes. The steam turbine or gas turbine will still be the common type of prime mover. Boilers for the generation of steam will still be in common use, but they will be considerably different from the present ones. Furnaces will not be required, nor coal- and ash-handling equipment. Boilers will probably consist of a high-pressure drum with an immersed lump of atomic material evaporating water by the heat of atomic fission. Of course, boiler feed pumps, steam piping, feedwater regulators, water-treating systems, and most other auxiliaries will continue to be necessary. It can be shown that in the production of atomic energy about 94 per cent of the invested capital of an electric utility system will continue to be useful; the other 6 per cent will have to be replaced by atomic-energy apparatus. This is not a very gloomy picture as far as the electric investment outlook is concerned.

LIMITING AVAILABILITY OF ATOMIC POWER

Undoubtedly, the Government will limit the production of atomic energy to large installations connected to the major electric-transmission networks so that the utmost economy of construction and operating costs may be attained and in order that the generation of this low-cost power may attain as nearly as possible a 100 per cent load factor.

The liberation of energy incident to the production of plutonium has also been suggested as a means of cheap power. Such plants, or piles as they are called, do involve important health hazards and they will probably be constructed only in locations remote from inhabited areas and surrounded by large tracts of vacant land. A considerable amount of engineering work should be done to develop the energy liberation of this process. At the present time the piles are water-cooled and although a great amount of heat is liberated in the process, the heat level is extremely low, being of the order of the heat which is rejected from steam-turbine condensers. It will be necessary to increase the pile temperature to a heat level, 700 F or higher, sufficient to generate high-pressure steam or to heat gases hot enough for utilization in a gas turbine.

These engineering developments are of considerable magnitude. However, they can be undertaken and solved within a reasonable period of time provided the Government approaches the problem in an intelligent and co-operative manner so as to stimulate engineering initiative and the investment of capital in the atomic-energy industry.

SUMMARY

In my opinion, the future of atomic energy, both from a military and peacetime standpoint, is dependent largely upon the action which Congress takes within the next few months.

Following is a program which would, in my opinion, lead to the speedy utilization of this new discovery for the promotion of peace and for the early and widespread distribution of its benefits to all mankind:

1 Congress should create an Atomic Energy Commission, preferably of civilian membership, but in no event under military domination.

2 Congress should provide for engineering participation in the activities promoted by that commission. Scientific discoveries should not be permitted to remain dormant because of lack of implementing engineering development.

3 Congress should appropriate funds for at least 10 years' use of the commission. This might be of the order of $1,000,000,000 or more. It would permit the commission to set up a long-range program and would make it unnecessary for it to lobby for additional funds each year.

4 The present production plants should have their operations reduced to at least one line per plant. The present full-scale plant operations must be costing over a million dollars per day. A large part of this money could be saved for future operation.

5 Plant operations should be continued on a commercial basis with special emphasis on the reduction of operating costs.

6 The United States should accumulate a store of bombs, planes, and pilots as determined by military needs.

7 This force should be placed at the disposal of the Council of the United Nations Organization for such punitive measures as they may determine.

8 The surplus production of atomic material should be made available to a limited number of industrial organizations and electric utilities for their use in developing atomic-power generation. These should be selected with special reference to their willingness and ability to carry on such development work.

On the Art of

CUTTING METALS

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FREDERICK Winslow Taylor's presidential address,[2] at the Annual Meeting of this Society in December, 1906, was one of the first comprehensive reports dealing with the subject of cutting metals. Among published reports of earlier notable metal-cutting experiments was that sponsored by eight prominent manufacturing concerns and the Manchester Society of Engineers. These were conducted in the period 1902–1903, the final report being written by Dr. J. T. Nicolson.[3] In 1901 a committee of the Verein deutscher Ingenieure, in collaboration with the managers of some large engineering works in Berlin, made a detailed series of experiments, the results of which were published.[4] In November, 1905, some American work by Prof. L. P. Breckinridge and H. B. Dirks of the University of Illinois was also reported.[5]

TWENTY-SIX YEARS OF STUDY

Taylor's results, as published, were based on experiments carried on almost continuously over a period of 26 years (1880-1906). His work became an American classic. Its clear and thorough presentation, with results so readily available for practice, won the confidence and admiration of every reader.

As a new foreman of a small machine shop of Midvale Steel, Taylor saw the need for what he called "part of the information necessary to establish" what later became known as the Taylor system of management. Fortunately, he was assisted by four men of technical training whose loyalty to the work and to each other was phenomenal. G. M. Sinclair devoted his entire time to this work from 1884 to 1887. H. L. Gantt succeeded Mr. Sinclair in July, 1887. Maunsel White joined the group in 1898, while Carl G. Barth began his work in 1899. The last three men worked with Taylor to the end of the project. Many others assisted in the actual running of the machines and in recording or tabulating the data.

Taylor listed three questions which had to be answered in the rough-machining of forgings and castings for final finishing cut: namely, What tool, what cutting speed, and what feed should be used. His experiments were based on twelve variables as follows:

1 Quality of metal cut.
2 Work diameter.
3 Depth of cut.
4 Feed.
5 Elasticity of work and tool.
6 Contour of cutting edge, together with its clearance and lip angles.
7 Chemical composition of tool and its heat-treatment.
8 Application of stream of water.
9 Tool life.
10 Cutting force.
11 Speeds and feeds possible in the lathe.
12 Power of the lathe.

TAYLOR'S WORK RESULTED IN MACHINING METALS FASTER AND AT LESS COST

Taylor's work was based definitely on the study of one variable at a time, whereas the experiments, involved in the earlier publications mentioned, are referred to by Taylor, as experiments "in which the joint effect of two or more variables were studied at the same time." Taylor's investigations resulted progressively in many conclusions and developments which made it possible to machine steel and cast iron faster and at greatly reduced cost. These are summarized from his work as follows:

(*a*) In 1881, a forged, heat-treated and ground, raised-face, round-nosed tool was found superior to the old-fashioned, forged, diamond-pointed tool.

(*b*) The use of coarse feeds, accompanied by their necessarily slow cutting speeds, was found to do more work than fine feeds with their high speeds.

(*c*) In 1883, a heavy stream of water poured directly on the chip of a steel forging and the self-hardening tool permitted an increase in cutting speed for the same tool life of from 30 to 40 per cent.

(*d*) Experiments were completed using round-nosed tools when varying the feed with constant depth of cut and when varying the depth with constant feed, to determine the effect of these two elements on the cutting speed.

(*e*) It was demonstrated that the cutting speed and tool life varied inversely.

(*f*) In the same year, the formulas giving a mathematical relation between the variables of the tests in parts (*d*) and (*e*) were developed.

(*g*) Cutting forces on hard-steel tires to remove cuts of varying feed and depth were determined.

(*h*) A set of experiments dealing with belting was started.

(*i*) Finally, in 1883, the power required to feed a round-nosed tool removing hard steel with varying depths and feeds was determined.

(*j*) In 1884, an automatic tool grinder was designed and a toolroom was set up.

(*k*) From 1885 to 1889, practical tables were made for a number of machines to give definite tasks to the machinist.

(*l*) In 1886, it was demonstrated that the thickness of chip had a much greater effect upon cutting speed than any other element.

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[2] "Art of Cutting Metals," by F. W. Taylor, Trans. A.S.M.E., vol. 28, 1907, pp. 31–279.

[3] "Experiments With the Lathe Tool Dynamometer," by J. T. Nicolson, Trans. A.S.M.E., vol. 25, 1904, pp. 637–684.

[4] "Schnelldrehstahl" ("Cutting Metals"), *Zeitschrift des Vereines deutscher Ingenieure*, vol. 45, Sept. 28, 1901, pp. 1377–1386.

[5] "Tests of High-Speed Tool Steels on Cast Iron," by L. P. Breckinridge and H. B. Dirks, University of Illinois, Engineering Experiment Station, Bulletin No. 2, November, 1905.

Contributed by the Management Division and presented at the F. W. Taylor Memorial Session on Management, during the Semi-Annual Meeting, Chicago, Ill., June 18, 1945, of The American Society of Mechanical Engineers.

(*m*) In 1894 and 1895, it was discovered that self-hardened steels gave a greater proportional gain in cutting soft metals than in cutting hard metals, contrary to previous opinion.

(*n*) In these years it was found that a heavy stream of water thrown on the chip and tool produced a 33 per cent increase in cutting speed for the same tool life when turning wrought iron with self-hardening tools.

(*o*) From 1898 to 1900, the discovery and development of the Taylor-White process of treating tools was made. These tools would do from 2 to 4 times as much work as the untreated.

(*p*) In 1899–1902, slide rules were developed to make the laws and formulas so far deduced available to the ordinary workman.

(*q*) In 1906, it was discovered that a heavy stream of water poured on the tool of high-speed steel and the chip of cast iron would permit an increase in cutting speed of 16 per cent.

(*r*) In this same year, it was found that the addition of a small quantity of vanadium to high-speed-steel tool material improved performance of the tool.

In presenting these data Taylor considered his ablest advocate, the slide rule, developed in 1899–1902.

From 1898 to 1900, the Taylor-White process was crystallized. Previously only Mushet steel and carbon tool steel had been used. He considered the period up to 1894, the era of plain carbon tool steel. This type had been used for centuries. From 1894 to 1900, he considered the era of self-hardening steel, called Mushet steel, developed in 1868, by Robert Mushet of Sheffield, England. From 1900 on was the era of high-speed steel. The faster and heavier cuts obtainable with this new steel revolutionized the art of cutting metals. New and more powerful machine tools were needed to use the steel to advanage and an immense impetus was given the improvement of equipment and method. Through the publication of Taylor's investigation, industry, in general, was stimulated to adopt his tools and methods.

PROGRESS SINCE TAYLOR'S TIME

Since Taylor's time, much further progress has been made in metals machined and in cutting tools. Many variations in high-speed steel have been presented to industry. Most of the high-speed-steel metal-cutting tools in use up to World War II were made from steel of the 18-4-1 type (18 per cent tungsten, 4 per cent chromium, and 1 per cent vanadium). This type of high-speed steel, similar to "Taylor's best," has been the most generally used of all types, and excellent tools are consistently made by many manufacturers. There was a slight demand during the prewar years for the so-called low-tungsten high-vanadium type of high-speed steel, containing about 14 per cent tungsten and 2 per cent vanadium. This high vanadium was also added to the 18 per cent tungsten steel and, in some instances, the vanadium was increased to 3 or $3^1/_2$ per cent. These tools gave increased hardness, toughness, and abrasion resistance required for machining very hard steels where slightly higher cost over the 18-4-1 type of steel was warranted by better performance.

In 1915, a cast nonferrous alloy, superior to high-speed steel, was introduced. This type of cutting tool is still undergoing continuous improvement. It permits cutting speeds from 25 to 100 per cent faster than the regular high-speed-steel tools on many classes of work. In 1928, a high-speed steel containing cobalt was announced as a super high-speed steel. This material, containing 4 to 12 per cent cobalt, is capable of doing heavy-duty work, and some hitherto impossible work, such as cutting 13 per cent manganese steel. In 1928, also, a new nonferrous cutting-tool material known as sintered tungsten carbide was developed in America. It had a hardness much greater than any former tool, except the diamond, and it had a high resistance to heat and abrasion. It was then being used in Germany to machine cast iron and brittle or abrasive materials.

In 1930, a sintered tantalum carbide for machining steel, otherwise quite similar to sintered tungsten carbide, was developed for the machining of steel. In more recent times, sintered tungsten carbide, sintered tungsten, titanium, and tantalum carbides combined, and sintered combined carbides of these metals have been developed in a number of different grades, each suited to a particular class of work. These metals are capable of operating at speeds 3 to 6 times those generally used with high-speed-steel tools.

Because of the shortage of tungsten, the development of the molybdenum high-speed steels was carried to a final conclusion, and these steels became generally used. In some, the tungsten was completely replaced by approximately 8 per cent molybdenum, while in others the tungsten was only partially replaced. These steels are also made containing cobalt for heavy-duty work. Each of the several types of high-speed steel must be given its own individual type of heat-treatment in order to secure its best performance. The use of these steels became mandatory during the war and many people accustomed to using the 18-4-1 type had difficulty in developing a heat-treating practice suitable for the molybdenum types of steel.

CUTTING TOOLS FOR VARIOUS METALS

The 18-4-1 type of high-speed steel or the molybdenum type is recommended for general use on all round work for the continuous-chip materials of the relatively low-carbon type. The high-carbon steels and tougher alloys call for the high-vanadium tool steels, such as the 18-4-2 types or the molydenum-tungsten type. The nickel and nickel-chromium classes of steels seem to respond best to machining when cobalt-bearing tungsten and molybdenum high-speed steels are used. Stainless steels, manganese steels, and cast steels seem to be machined most economically with the high-cobalt type of tungsten or molybdenum steels. The high-vanadium type of tungsten steel has been found to give excellent results when machining the broken-chip type of materials, such as cast iron and nonferrous metals, where failure is usually by flank abrasion rather than cupping. Equipment for the heat-treatment and metallurgical control of tool quality has attained a high state of development and uniform tool performance is generally assured.

During the last few years a number of treatments of steels have been developed coming under the heading of cyaniding or nitriding, the so-called case treatments, as well as the plating of tools with chromium. These surface treatments usually must be given after each grinding if the lip face is removed. They are most effective in light operations or on abrasive materials.

Where Taylor had hard, medium, and soft steel, and hard, medium, and soft cast iron to machine, the present-day field covers literally thousands of types of steels and nonferrous metals, most of them in hot- and cold-finished bars and tubes, forgings, and castings. There are many carbon and alloy steels, plain and alloyed cast iron, malleable and pearlitic irons, and many high- and low-strength nonferrous metals of copper, aluminum, zinc, and magnesium, and a great variety of types and forms of nonmetallic plastics. Dozens of these metals are now being machined at hardnesses not even thought of by Taylor.

A whole new industry of cutting fluids for many specific purposes has been developed, whereas Taylor experimented only with dry cuts and with a tool flooded with water (soda water).

Present cutting fluids consist essentially of soluble oils (to be mixed with water to form an emulsion), petroleum oils, compounded petroleum and fixed oils, and oils with additives such as sulphur, chlorine, graphite, etc.

In view of the great variety of present-day materials to be machined, cutting-tool materials, and cutting fluids, most of the mathematical relationships developed by Taylor are now only generally correct.

FORMULA FOR TOOL QUALITY

In 1894, Taylor "hit upon" the practice of basing tool quality on the value of the cutting speed required to make the tool fail in 20 min. The following year, the relation between the cutting speed and tool life, as represented by the formula VT^n = const, was determined. One possible error in Taylor's work in using the cutting speed for a 20-min tool life as a basis of tool quality was that he was considering only one of the variables involved in the cutting speed - tool life relation. At the present time, the practice is common to determine the tool life for a number of different cutting speeds. These points plotted on logarithmic paper indicate a straight line the slope of which is represented by n, the exponent of T. The height of the line is represented by the constant C, the cutting speed for a 1-min tool life. It is, therefore, possible to determine a common value of cutting speed for a 20-min tool life as the rating for a number of tools, but these values or ratings would be different were a tool life other than 20 min to be used as a standard time of failure.

This procedure is now outlined in an American Standard entitled, "Life Tests of Tools Made of Materials Other Than Sintered Carbides." Taylor assumed that the slope n, of all the cutting-speed tool-life lines for high-speed-steel tools turning steel, was equal to $^1/_8$. In a comprehensive series of tests, conducted a few years ago at the Bureau of Standards, it was concluded that this value should be $^1/_7$. Over a number of years the author has found that these values are general, but may vary appreciably, and cover the range of from $^1/_3$ to $^1/_{25}$. A large number of lines may pass through the point for the cutting speed for a 20-min tool life at different slopes, but may not have corresponding values of speed for any other tool life.

WIDE RANGE OF TOOL SHAPES REQUIRED

Taylor's work, which was devoted to roughing cuts only, resulted in the standardization of forged, raised-face, round-nose high-speed-steel tools having two values of side rake, namely, 14 and 22 deg, each with 8 deg back rake. The 14-deg side rake was for cast iron and hard steel, and the 22 deg for soft steel. A much greater range is needed to meet today's problems. Further, these rake angles must be adapted to each of the different types of cutting-tool materials used today. Finishing cuts now constitute a large part of the work of machining, and these often require tools of special shape and contour of cutting edge. Using normal tool shapes for each tool material, when turning an alloy steel, annealed, cutting speeds for a given tool life were found to be, respectively, 1 for carbon tool steel, 2.8 for high-speed steel, 5.8 for cast nonferrous metal, and 11 for sintered carbide.

Taylor standardized his tools to have a range of nine sizes of shank, from $^1/_2$ in. wide × $^3/_4$ in. high, up to 2 × 3 in., for both cast iron and steel. His figures show that for the same depth of cut and feed, the cutting speed for a given tool life of 90 min is practically the same for tools of all sizes when turning the same metal under the same conditions. The forged type of tool has been superseded now, except for some special shapes and sizes, by solid hardened bars, the point of which is ground on one or both ends. Some of these bars are large enough to serve as tool and shank and others of smaller size are held in toolholders as bits. The sizes of these bars are now American Standards for both square and rectangular solid and tipped tools. It has been found that the tool life for a given speed for these modern tools is also practically independent of the size of the tool. However, the tool should be large enough to withstand the cutting force.

TAYLOR'S CUTTING-SPEED FORMULA

The formula presented by Taylor to determine the cutting speed for a 20-min tool life, based on the tensile strength and elongation, was shown to be correct within a few per cent for many of the steels he machined. Bureau of Standards tests, made a few years ago, checked this formula with a large number of alloy steels, annealed and hardened, and showed that the majority of the results were within plus and minus 20 per cent. A few were outside this tolerance. In many steels used today, additives such as sulphur, lead, etc., may increase the cutting speed for a given tool life by 20, 30, or even 40 per cent without changing the physical properties appreciably. However, the speeds of a set of steels of similar analyses and physical properties but from different heats or from different manufacturers may be greater than these limits permit.

Taylor rendered a service to management in presenting his "data from which to decide how long each size tool should be run before being reground." These data applied to all of his standard tools with shanks from $^1/_2$ in. wide to 2 in. wide. These tools were of the forged type and so the data do not apply to present-day tools ground from bars or bits, hardened in the furnace in quantities.

Taylor's report did recommend that water or borax water be discharged on the tool and chip at a volume not less than 3 gpm. It has been determined since, that cutting fluids (water, emulsion, and oils) should be applied at this volume per single tool and that the best speed is obtained when the cutting fluid is not far from room temperature, i.e., within a range of from 70 to 85 F.

USE OF SLIDE RULES AND NOMOGRAPHS

The slide rules used by Taylor were reported as being very satisfactory. They served adequately in helping machine operators properly set up their machines. I had the pleasure of working with Carl Barth in preparing several slide rules of this type. My feeling is that they were scientific only in a limited sense, in their speed selection, as based on the material character. Slide rules and nomographs of today, based on tests of a specific limited range, are more accurate. Even these, in general, are inadequate for management. Hardness is perhaps the most convenient and reliable basis for evaluating tool life - cutting speed relations, and yet its uniformity lies in limited ranges of values for like materials. Much has yet to be done to perfect these aids to management.

Present-day management is interested in these problems of turning. It is interested in much more. For example, other metal-cutting processes, such as drilling, broaching, threading, screw-machine work, gear cutting, grinding, and milling, each has peculiar characteristics and variables which require study. Although a great deal of study is being devoted to each of them, none is more complete than turning.

Largely by accident, a new technique was recently developed in milling hard steel with negative-rake sintered-carbide cutters. Many companies have experimented or conducted practical tests in this field. A great deal of duplicated effort has been expended and, even yet, the results, good and bad, have not been co-ordinated to the end that industry can use the best practice in its plants.

(*Continued on page* 313)

MEASUREMENT *of* SURFACE ROUGHNESS

By C. J. POSEY

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THE characteristic of a surface that we call its roughness is familiar to everyone. Early in life we learn the difference between rough and smooth surfaces, and with practice we may become remarkably skillful in detecting, by the senses alone, very slight differences in roughness.

The scientific measurement of roughness, however, presents a difficult problem. By exercising sufficient care and ingenuity, it is possible to construct equipment that will measure and even record the linear deviations of the profile of a surface, along a selected path, from that desired. The difficulty lies in deciding what is to be done with this record. Apparently the irregularities of the profile should be summarized in some way, and numerical quantities obtained that will adequately characterize the roughness.

Present practice in this country is to derive a single numerical value, the root mean square of the deviations from the average. British practice favors using the arithmetic-average height, measured outward from the center line (average). Neither system takes all factors into account, though either can be used quite satisfactorily in comparing surfaces of similar materials produced by similar finishing methods.

The concept of similar or identical surface roughness is difficult to define precisely. For example, two surfaces might have identical values of root-mean-square deviation from the average, and yet be very different in their frictional resistance to fluid flow. Although it is likely that some difference between the two surfaces could be detected by direct visual observation, it might be necessary to study the highly magnified profiles carefully before any differences that might produce the variation in frictional resistance could be found.

On the other hand, the profiles of two surfaces, indistinguishable from the standpoint of appearance, frictional resistance, and every other test of their properties, would not need to be exact duplicates. The two profiles could "look alike" and "act alike" but not necessarily coincide when superimposed. In other words, the identicalness of rough surfaces does not require perfect geometrical similarity in the Euclidean sense, but rather a sort of statistical similarity. This statistical similarity can be measured by the method described herein.

MEASURING STATISTICAL SIMILARITY OF SURFACES

The lower curve at the left in Fig. 1 represents a portion of a highly magnified surface-roughness profile. The ordinates y represent the varying distances of the profile above or below a straight line at or near the average level of the surface. Abscissas x represent distances along the profile, measured parallel to the line of zero values of y. This x-y curve, then, is the type of record that could be obtained by a roughness-measuring machine. The degree of magnification would, of course, be selected to suit the range of size of the surface irregularities to be measured.

The curve immediately above the x-y curve, or profile, is a plot of values of

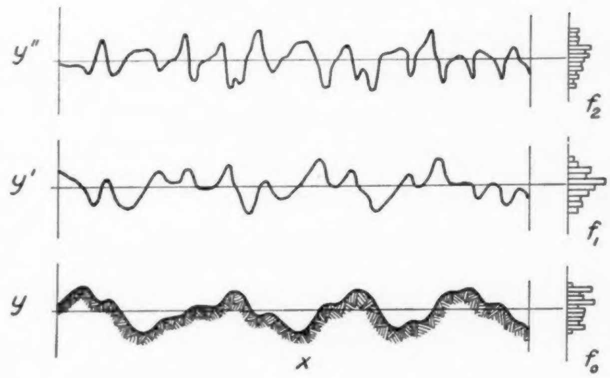

FIG. 1

$$y' = \frac{dy}{dx}$$

from the curve below. At any point, then, y' represents the slope of the profile. The top curve in Fig. 1 is a plot of values of

$$y'' = \frac{dy'}{dx} = \frac{d^2y}{dx^2}$$

so that it represents, approximately, the degree of curvature (reciprocal of radius of curvature) of the x-y profile.

If, now, the range of values of y is divided into a large number of equal increments, and the percentage of the total distance x for which the curve lies within each increment determined, a histogram[1] of values of y can be plotted, as shown at the right of the profile record. If the number of increments of y is made very large, and the total length of profile x included in the computation very great, a smooth curve known as a frequency curve can be drawn, representing the limit that a histogram, made up of an infinite number of rectangles, would approach. Practically, however, it is better to work with the histogram, using a reasonable number of class intervals, say, 10–20 covering the range of y.

The histogram f_0, representing the frequency distribution of depths, will be referred to as the "depth distribution," or "depth histogram." The histogram f_1, prepared in a similar manner from the y' or slope curve, will be referred to as the "slope distribution," and the histogram f_2, summarizing the data of the y'' or degree-of-curvature plot, will be referred to as the "curvature distribution."

The three distributions f_0, f_1, and f_2 characterize the roughness of a profile quite completely. The analysis applies to either regular or irregular profiles, although apparently its

[1] For definition of this and other statistical terms used, see "Handbook of Mathematical Statistics," edited by H. L. Rietz, Houghton, Mifflin Company, New York, N. Y., 1924, p. 20, et seq.

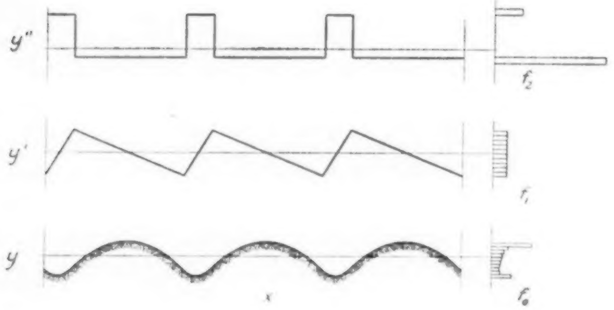

FIG. 2

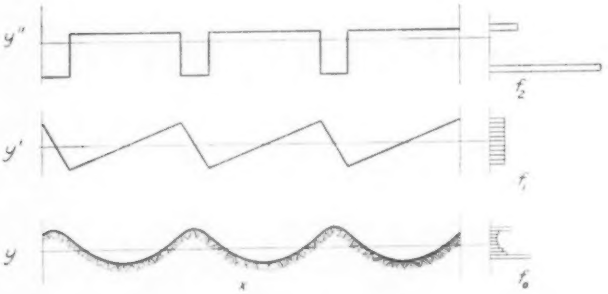

FIG. 3

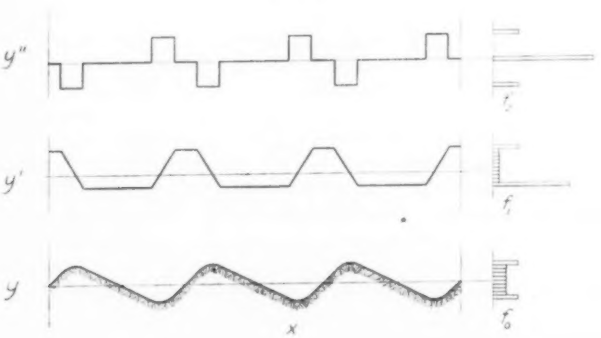

FIG. 4

application is restricted to curves without overhanging portions. If two profiles yield depth, slope, and curvature distributions that are the same, the roughnesses are said to be statistically identical.

The average or center value of the depth is seen to correspond to the location of the center of gravity of the depth histogram, and the root-mean-square measure is evidently the radius of gyration of the histogram about its centroidal axis. That these two measures provide but fragmentary evidence as to the roughness may be seen by comparison of Figs. 2 and 3. The roughness shown in Fig. 2 will fit exactly into that shown in Fig. 3, so that the average, the root mean square, and the arithmetical average are identical for the two surfaces. Their physical properties would undoubtedly be very different. The depth and curvature histograms are identical in shape, but reversed.

If two roughnesses of the type represented in Fig. 2, geometrically similar, but differing in size, are compared, the histograms will be similar in shape and position, differing only in size. Thus the root-mean-square measure would adequately characterize the difference. This is just what the experience in practice has been; the root-mean-square or arithmetic average of deviations measures are satisfactory for comparing surfaces of the same material finished by the same process.

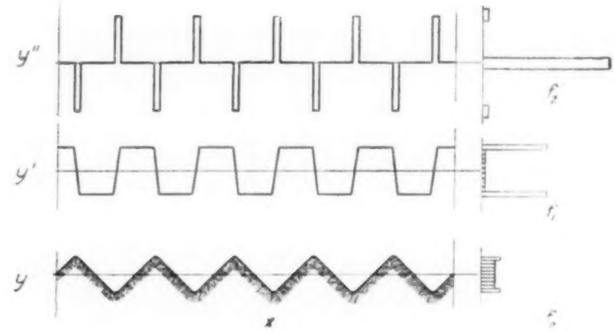

FIG. 5

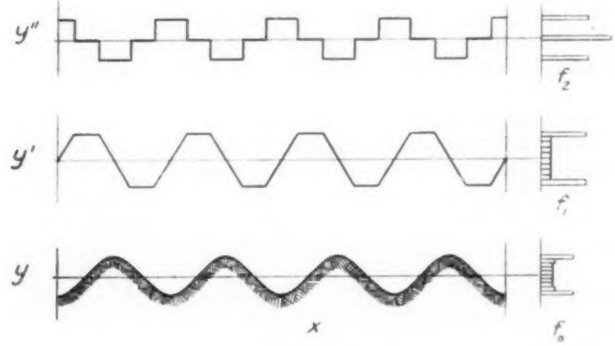

FIG. 6

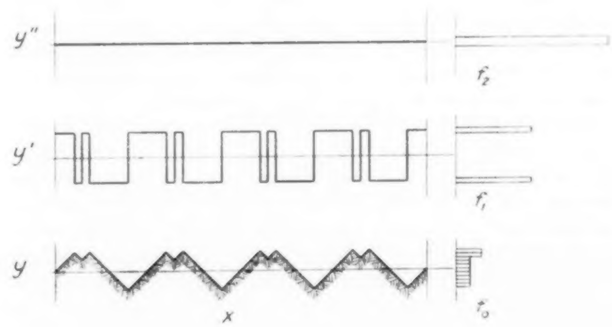

FIG. 7

The geometrically regular roughnesses of Figs. 4 to 7, inclusive, show the effect of different types of profile configurations upon the depth, slope, and curvature histograms. Fig. 4 shows why a surface having a profile with an unsymmetrical f_1 distribution will have directional light-reflecting characteristics. Simple repeating geometrical profiles are used for these figures so that the effects illustrated will "show up" immediately in the histograms. Actual roughness records would of course have to include a very large number of peaks and valleys in order to establish histograms of characteristically defined shape. The task of computing the histograms for irregular records is tedious and lengthy. Progress has been made in developing equipment to do this work automatically.

In plotting histograms of statistically rough profiles, the results from two adjacent equal lengths of record must be very nearly the same. If not, the lengths summarized were not long enough, or the roughness of the profile varies along its length.

(*Continued on page 338*)

Experiences With

CARBIDE-TIPPED TOOLS

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CARBIDE-tipped cutting tools for milling, drilling, boring, and turning had been in use at Delco Products Division of General Motors Corporation plant at Dayton, Ohio, for some years before the recent war. However, their use was confined mostly to cast-iron applications for automotive shock absorbers and electric motors.

With the advent of the war, the necessity arose of achieving greater production with fewer people, fewer pieces of equipment, and with the man-hours necessary for the schedule rapidly becoming in excess of 24 hours per day per man. One of the major projects was machining landing-gear struts for aircraft, with steels of aircraft quality, machined both in the normalized and hardened state, with machining conditions running as high as 42 Rockwell C.

Here, in particular, the need of greater production became manifest. However, delivery of equipment was becoming extremely critical, schedules were going many times higher than had been anticipated, and an insufficiency of available floor space added to the difficulties. As a result of these production handicaps, it was decided to attempt a solution to the problem of getting more production per machine-hour, by studying all aspects of carbide-tool application, doing the job logically, systematically, and practically. The approach was resolved into such brackets as (1) tool engineering, (2) tool follow-up and processing, (3) tool manufacture, (4) tool maintenance.

TOOL ENGINEERING AND FOLLOW-UP

To implement the program, several of the tool-engineering-department staff were selected who had had fundamental experience in feed, speed, horsepower application, knowledge of equipment, and a thorough understanding of the product to be manufactured. To one of these engineers was assigned a group of practical artisans termed "tool process men," whose particular duty it was to analyze the type of tool required to do a given job to the best advantage, and to whom were delegated special individual operations to process to the ultimate degree. Shortly after they had been chosen and indoctrinated by the engineering group with what knowledge had been accumulated over a period of years prior to the war, they were sent to the Carboloy Company for additional training. When sufficient facility had been acquired, shift assignments were made so that representation on the job was placed on the basis of 24 hours a day. These men were thus constantly available to the supervision of the manufacturing departments for help and advice as to the most practical method of doing the operations involved.

After the tool engineer responsible for a given project had estimated the ultimate production that might be procured on specific operations, tool process men were assigned to those operations and it was their duty to go out and get production. Not only were these men capable of determining the cutter basic designs, but also of manufacturing the most practical cutters for the specific job and giving them a thorough tryout.

However, it was not long before we discovered that it would be almost impossible to get the number of cutting tools required to maintain production. Steps were therefore taken to set up a department devoted entirely to the manufacture of carbide-tipped tools.

TOOL MANUFACTURING

During the period of peak production, the tool-manufacturing department made as high as 20,000 tools per month. This may sound as though tools were being misused. However, when one looks at the schedule of almost 1600 sets of landing gears per month produced in a plant operating around the clock 7 days a week with each set consisting of two main legs and one nose leg for such airplanes as B-24 Liberator, B-25 Mitchell, B-26 Martin, TBY for Consolidated Vultee, A-26 Douglas Invader, P-51-H Mustang, and the FR-1 Ryan, it will be realized what a tremendous number of parts were involved which necessitated the use of cutting tools.

In the process of manufacturing cutting tools, practically all of our last issue of tools were made with cast Mechanite shanks. The shanks were placed on the surface grinder, Fig. 1, in lots of 100, and two surfaces were ground parallel. The pocket for the tool was cast and merely touched up by milling, Fig. 2, with a zero-rake milling cutter running in the neighborhood of 1200 sfpm. All tips were brazed on by induction-heating, Fig. 3; the equipment consisting of a continuous rotary turntable on which the tools were placed and passed between induction coils for brazing. The angles were then ground on the tool, Fig. 4, to a specified tool engineering drawing.

A carefully kept cost record showed that we were able to make tools anywhere from 30 to 60 per cent less cost than we were able to buy them, because we knew our problems better than the outside tool manufacturer. These tools gave much longer life than those purchased, which is no reflection on the ability of the outside tool concern to make good tools, since we were able to incorporate certain refinements over which the outside purveyor had no control.

TOOL MAINTENANCE

The manufacture of the tools and their maintenance were carefully controlled. After a tool design was developed, a standard sheet was drawn up containing all the data pertinent to its application. This drawing was issued by the tool-engineering division to the toolmaking department, to the tool-maintenance department, and to the general foreman of the department in which the tool was to be used. When tools were returned for regrinding, they were reground to the original drawing. This eliminated the bad features of job setters changing angles to suit their own particular ideas. No grinding wheels were allowed on the job. All carbide tools had

Contributed by the Research Committee on Metal Cutting Data and Bibliography and presented at the Fall Meeting of the Cincinnati Section, Cincinnati, Ohio, Oct. 2–3, 1945, of The American Society of Mechanical Engineers.

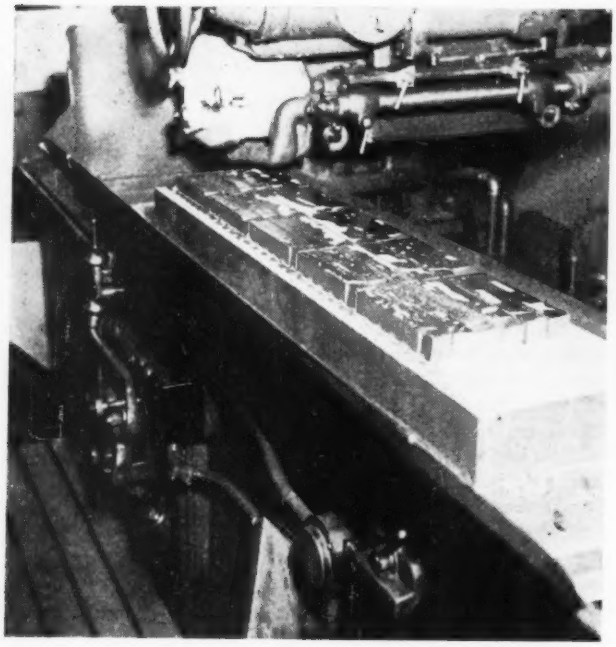


FIG. 1 SURFACE-GRINDING TOOL SHANKS

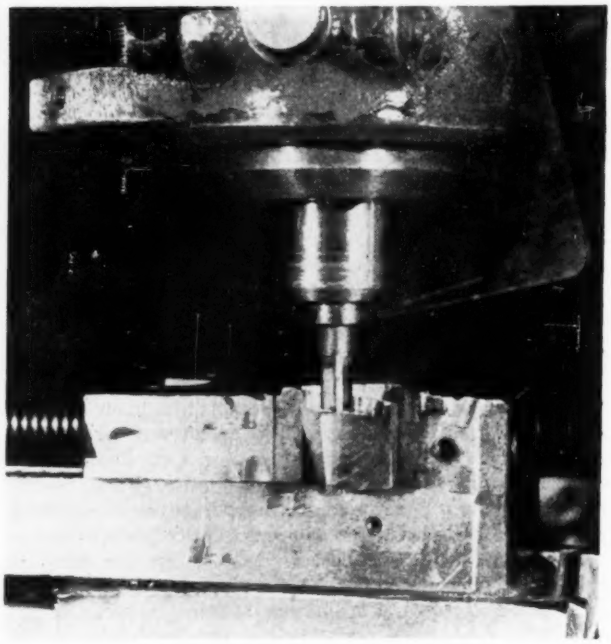


FIG. 2 MILLING POCKET FOR CARBIDE TIP

FIG. 3 INDUCTION-BRAZING CARBIDE TIPS ON VARIABLE-SPEED ROTARY TABLE

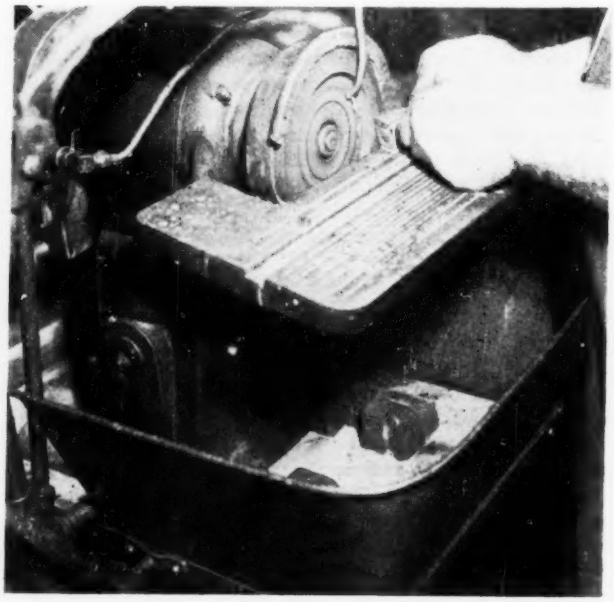


FIG. 4 GRINDING CARBIDE-TIPPED LATHE TOOL

to be returned to a tool crib, thence to the tool-grinding room, which was separate and distinct from the tool-manufacturing department. Here the tools were reground to the original drawing and then returned to the proper production department.

Tool changes were made only upon receipt of an official "tool-change request," signed by authorized individuals. At that time, all old prints applying to the tool in question were removed and destroyed, and new ones placed in the files.

A knowledge of the correct grinding procedure for steel-cutting carbides is of prime importance. Improper grinding methods produce weaknesses in carbide tips that are not inherent in the material; cracks and checks are formed in the carbide which can be avoided if the proper care is taken in grinding. After all finished cutting faces are ground, we add a hand-lapping operation in order to give all cutting edges a dulling effect by using a 320 × 400-grit diamond vitrified honing stone.

All cutters must pass a rigid inspection before being placed in use. Before and after grinding, carbide-cutting tools are given the Zyglo magnaflux treatment to detect whether any carbides require replacement because of cracks which may have formed in brazing or in grinding. All single-pointed turning and boring tools are rough- and finish-ground by hand.

GENERAL ENGINEERING

It has been our experience that the greatest mistake made by users of carbide-tipped tools is a tendency to think of them in terms of high-speed tool bits. This immediately leads into the trap of making tools with shanks which are too small. It is our practice to use the largest possible shank that we can get into the toolholder or machine. In turning, we never use less than a $^5/_8$-in. square, and preferably a $^3/_4$-in. square. In boring, $^5/_8$-in. round is preferred. However, there are cases where we have had to go to a $^1/_2$-in. round

The next pitfall is failure to make toolholders rigid enough. Unless the tool is supported rigidly, and the tool block made massive enough and fastened rigidly to the machine member, tool life will be decreased tremendously, the type of finish will be unsatisfactory, and size will not be held.

As an example, we were called in about a year ago to look at an operation for turning and boring an aircraft part at another plant. The part was a forging made from X-4130 quality steel, normalized, hardened, and drawn to about 33 Rockwell C. The forging had a great amount of material to be removed. The machine-tool builder designed the tools in the manner just noted, i.e., too small and not rigid. The grade of carbide tip was not correct, in our opinion, and the user of the equipment was not too familiar with carbide-tipped tools. In their zeal to get the job into production, we found on the machine aluminum-grade, cast-iron-grade, and steel-cutting-grade carbides being used promiscuously. We were asked to help them out. One of the first things we did was to throw away the toolholders. The next step was to design and make the heaviest tool bit that it was possible to get on the machine, which was

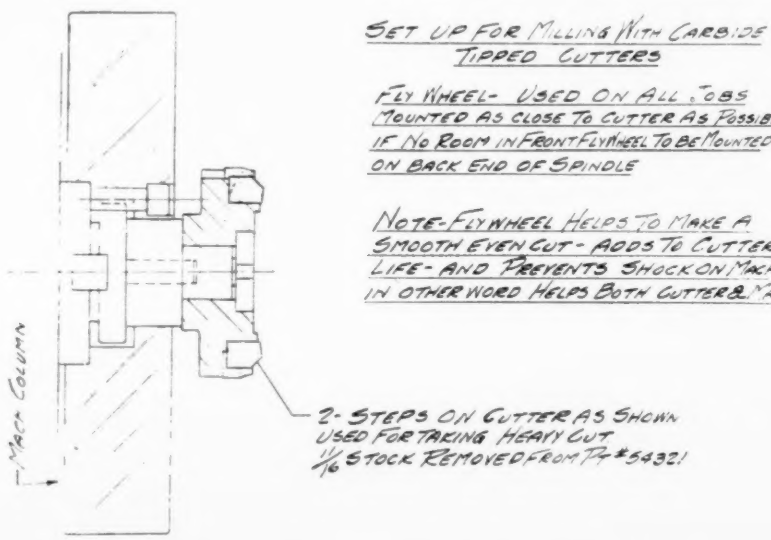


FIG. 5 SETUP FOR MILLING WITH CARBIDE, SHOWING FLYWHEEL

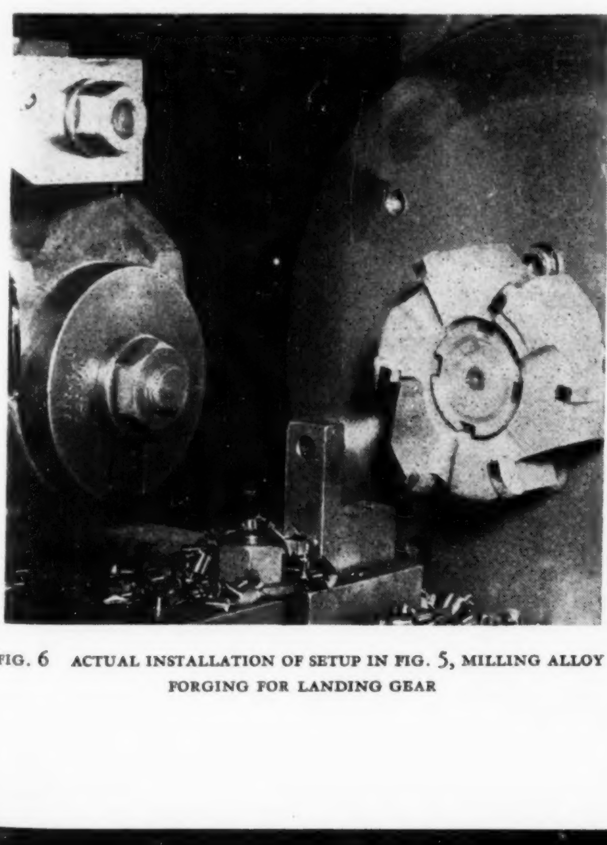


FIG. 6 ACTUAL INSTALLATION OF SETUP IN FIG. 5, MILLING ALLOY FORGING FOR LANDING GEAR

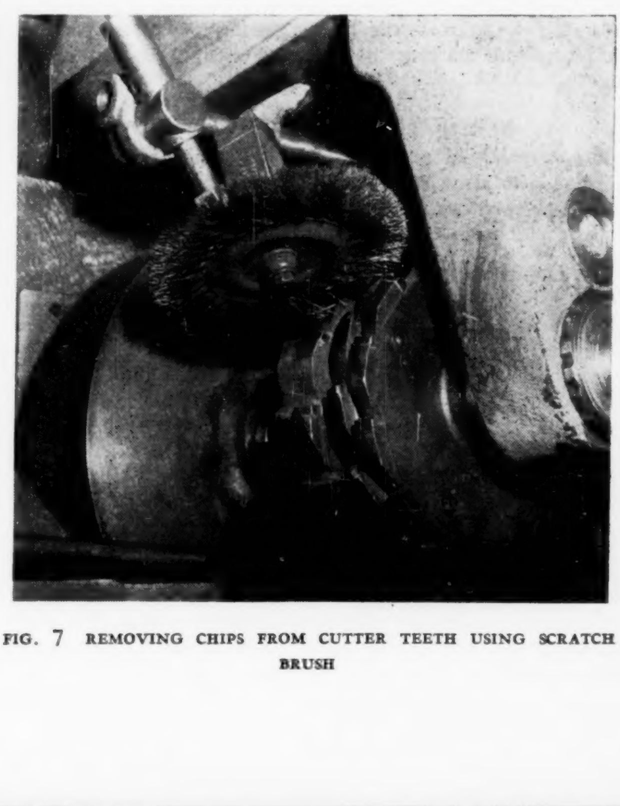


FIG. 7 REMOVING CHIPS FROM CUTTER TEETH USING SCRATCH BRUSH

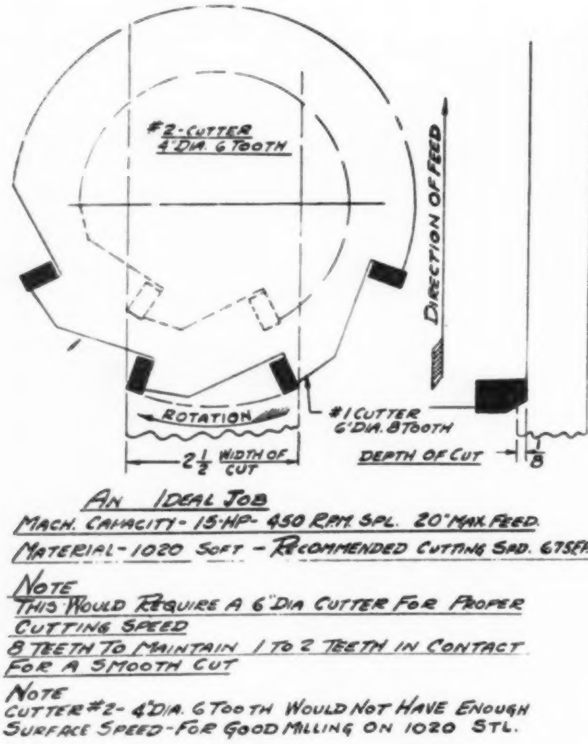


FIG. 8 THE IDEAL JOB FOR CARBIDE-MILLING

(Part to be milled, S.A.E. 1020, Brinell 190; recommended surface speed, 675 rpm minimum; maximum spindle speed of machine, 450 rpm; correct-diameter cutter, 675/452 × 0.262 in., 5.7 in. diam, use 6 in.)

a six-spindle chucking machine. It was also determined that with the correct feeds and speeds within the horsepower rating of the equipment, it was possible to get 125 to 150 pieces per hr. At the time our tool engineers were called in, they were getting only 150 pieces in 8 hr, because of tool trouble and the associated troubles that go along with such a job. Ten days after we started, they were getting 150 pieces per hr, and where four machines had been required, three were made idle.

MILLING WITH CARBIDE-TIPPED CUTTERS

The essentials of good milling with carbide-tipped cutters are fundamentally the same as the essentials of good milling with high-speed steel cutters, omitting the use of the proper coolant which is not desirable in carbide-milling:

1 Machine must be in good condition:

(a) Gibs should be properly adjusted.

(b) Backlash in the feed mechanism should be reduced to a minimum.

(c) Drive belts should be checked to see that a full set is on each machine, and that they are properly adjusted and in good condition. The clutch, if one exists, should also be checked.

2 The work-holding fixture must hold the work rigid and must be securely fastened to table.

3 The correct cutters must be selected for the job.

4 Proper feeds and speeds should be selected and used.

Although the items mentioned are essential for both conventional and carbide-milling, they are far more exacting when milling with carbide, as the machine must operate at higher speeds, greater feeds, and must work more nearly at its maximum capacity.

The work-holding fixture must hold the work more rigidly. Yet, due to the increased feed, which means a shorter milling time, the fixture should be so designed as to cut the loading time to a minimum, insuring more pieces per hour.

Quite often the existing milling machine requires the use of a flywheel to aid in getting a smooth flow of power to the cutter. Fig. 5 shows the arrangement for flywheel installation, and Fig. 6 shows this arrangement actually installed on an existing machine.

METHOD OF REMOVING CHIPS FROM CUTTER

In conventional milling, a coolant is generally used which, to a certain extent, washes the chips out of the cut and off the cutter, especially in the case of slotting or peripheral cuts.

As no coolant is used with carbide-tipped cutters, some of the chips cling to the teeth of the cutter and must be mashed in two, before the carbide presents its cutting edge to the work. This is very detrimental to the carbides. In some instances a blast of air is used to blow the chips from the teeth, but in some departments air is not available, and if it were, this practice is noisy, annoying, and expensive.

For this application, by mounting a round wire brush on a spindle so that the rotation of the cutter revolves the brush across the face of the teeth, it has been found possible to wipe the chips free of the carbides, doing a better, cleaner, and cheaper job than air, without the nerve-racking noise; Fig. 7 shows the installation.

CARBIDE-MILLING WITH PRESENT EQUIPMENT

By adhering to the essential fundamentals of good milling practices, carbide-milling can be done on practically any machine in good condition, providing the power of the machine is not exceeded. The smaller the power of the machine, the less metal can be removed. Cutting speeds and correct chips per tooth must be maintained. This means the cutter must be

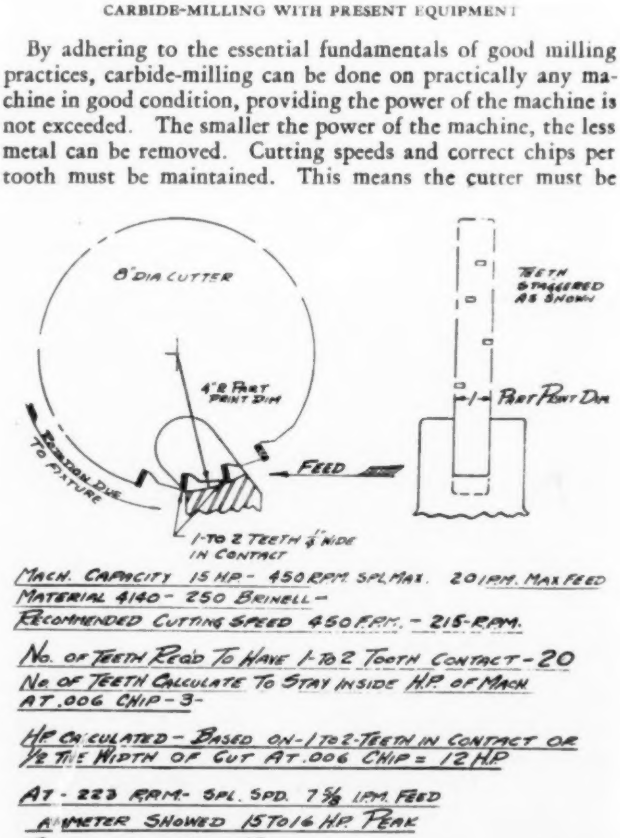


FIG. 9 AVOIDING SHORTCOMINGS OF EXISTING EQUIPMENT BY STAGGERING TEETH

designed to fit the job, and feeds and speeds must not be altered by the operator (see Fig. 8).

From the example given in Fig. 8, it will be seen that many of the shortcomings of present equipment can be overcome in the proper selection of cutters. This will be discussed more fully with our experience in cutter design (see Fig. 9).

CUTTER DESIGN TO FIT PRESENT EQUIPMENT, OR EQUIPMENT DESIGNED ESPECIALLY FOR CARBIDE-MILLING

Much truth may be spoken regarding cutter design, which will mean absolutely nothing if not put into practice. The following considerations always enter into the design of our cutters:

1 Material to be milled (this is an index to the grade of carbide to use and, to some degree, the rake angles).

2 Shape of the part to be milled, or the shape of the metal that is to be removed. This determines the type and size of cutter to be used. It has a very definite bearing on rake angles.

3 Width and depth of cut, material to be milled, and horsepower of mill are the deciding factors in number of teeth to be in cutter.

4 After considering the material to be cut, the shape of the part, the width and depth of cut, and horsepower of machine, we should have a very definite idea of the cutter to be used.

5 So far, we have considered the cutter in relation to the job only, and we should now consider the cutter from the construction-service viewpoint, Fig. 10, as follows:

Carbide should be away from body to prevent cracking.

Approximately 25 per cent of the thickness of the carbide should overhang the body to facilitate grinding and protect the cutter body.

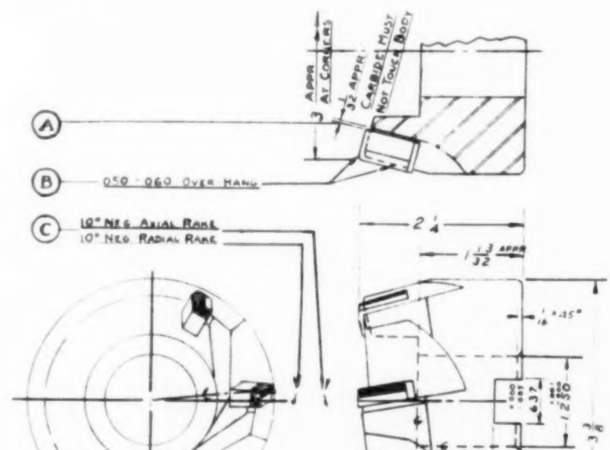


FIG. 10 TYPICAL DELCO PRODUCTS CUTTER DESIGN STANDARD SHEET

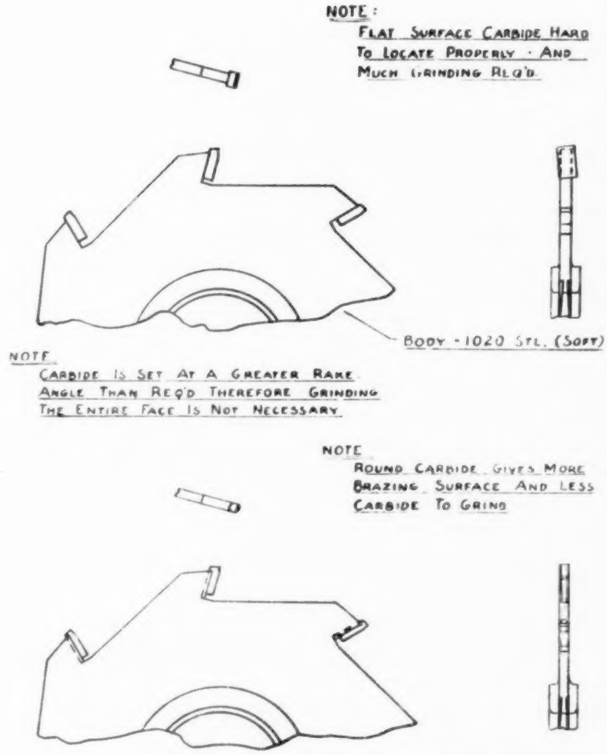


FIG. 11 ILLUSTRATING METHOD OF ATTACHING CARBIDES TO NARROW CUTTERS TO REDUCE GRINDING TIME AND ELIMINATE BRAZING FIXTURES

Carbides are set in at 5 deg negative radial rake and ground to 10 deg negative radial rake. This presents a narrower surface to the grinding wheel, evolves less heat while grinding, less teeth can crack, and nicks are easy to grind out.

By setting the teeth in as stated, we save grinding time on the face of the teeth.

The primary land is $^{3}/_{32}$ in., which is much wider than the usual $^{1}/_{32}$ in. This aids the honing, as it is very difficult to hone a $^{1}/_{32}$-in. width on top of the tooth and keep it flat.

Fig. 11 shows a slotting saw for copper, and since it is very difficult to hold small pieces of carbide while brazing, we decided to use round carbide. By milling a round seat for the carbide, the problem of location was solved. A carbide nearly to size could be used, which cuts the grinding time to a minimum. Fig. 11(*a*) shows a slotting cutter as it usually appears with rectangular carbides before grinding; Fig. 11(*b*) shows round carbide.

Radial Rake. Radial rake protects the cutting edge and has much to do with the life of the cutter and should be determined from the material and the nature of the cut. It will be seen in Fig. 12 that when the tooth enters work at point *A* and cuts from point *A* to point *B*, the cutting edge is well protected and would not require as much negative radial rake as a tooth entering the work at point *B*.

Fig. 13 shows a slotting cut. This type of cut requires more negative radial rake than the cut shown in Fig. 12.

Axial Rake. Axial rake protects both the cutting edge and the point of the tooth, but not to the same degree as the negative radial rake. The material, the nature of the cut, and the depth of cut should control the axial rake angle.

Cutting Speeds. As previously mentioned, the essentials of good milling practice are more exacting in carbide-tipped mill-

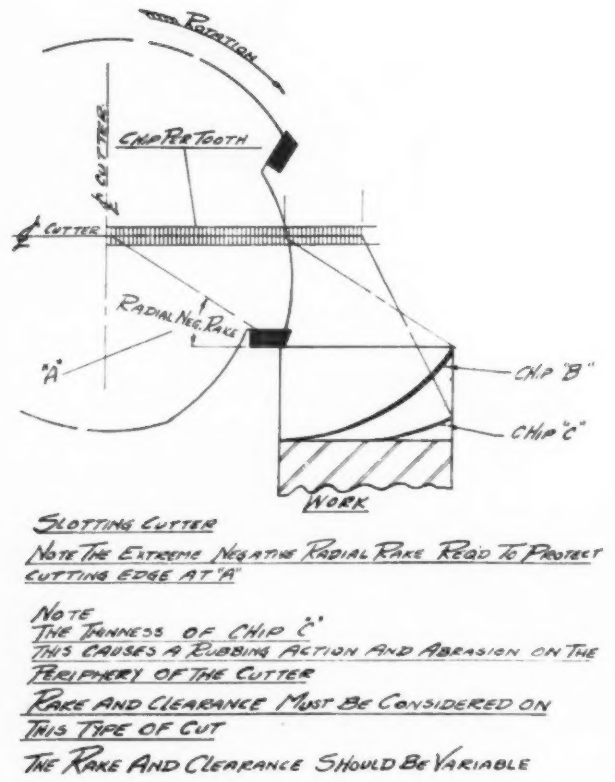


FIG. 12 DESIGNING A CUTTER TO GET MAXIMUM EFFICIENCY FROM RAKE ANGLE

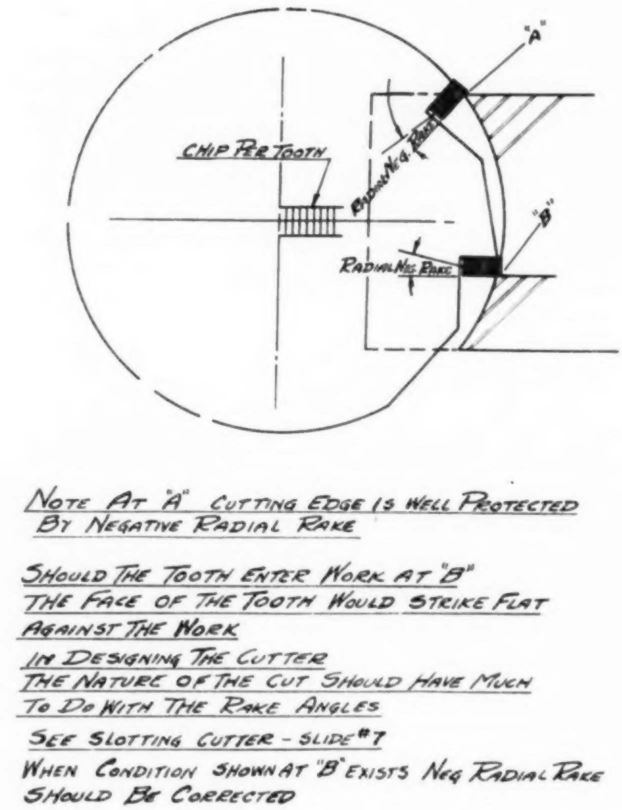


FIG. 13 A CONDITION THAT OFTEN ARISES IN SLOTTING CUT

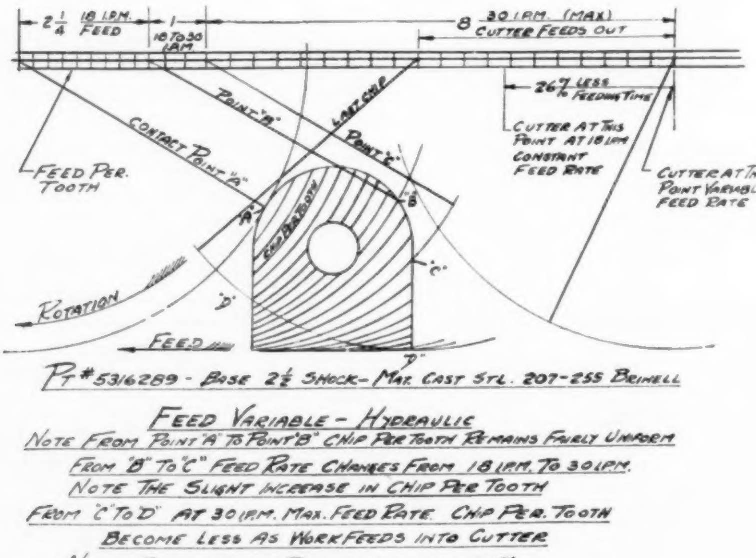


FIG. 14 ADVANTAGE OF HYDRAULIC FEED USING VARIABLE FEED RATES DURING THE CYCLE

ing than in conventional milling. The correct cutting speed for the material to be milled heads the list. Practically all research on the matter and experience indicate that too high a rate of cutting speeds leads to short cutter life. Charts showing recommended cutting speeds for various materials have been published by the Cincinnati Milling Machine Company, and these speeds in our experience have proved to be substantially correct. The most important factor in selecting cutting speed is to know your material.

Feeds. The rate of feed should be determined by the number

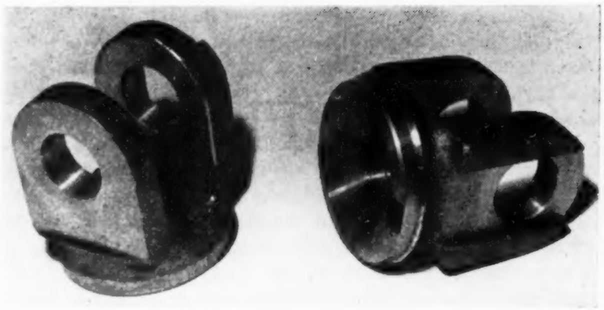


FIG. 15 PART MILLED WITH THE CYCLE SHOWN IN FIG. 14

FIG. 16 SAFETY FEATURE OF NARROW CARBIDE CUTTERS BECAUSE OF SOFT CUTTER BODY

of teeth in the cutter and the revolutions per min of the spindle.

The feeding mechanism itself should be smooth and free of backlash. This is very essential in a slotting cut, as the cutter tends to drag the work in. For carbide-milling, hydraulic feed is ideal. On conventional milling, objection to hydraulic feed has been raised because the feed increases as the oil warms up. In a case where the feed rate is 2 ipm in conventional milling and some slight increase in the oil being metered out causes the feed rate to go to 3 ipm, an increase of 50 per cent in the feed will have occurred. Where carbide-milling is involved, the feed rate is always high, usually 20 ipm or more, so that slight increase in metering, due to change in oil viscosity, would mean only a slight increase in the feed rate and would probably do more good than harm.

A very definite advantage of hydraulic feed is shown in Fig. 14, i.e., the flexibility of the feed, which permits it to be varied during the cutting cycle, thus maintaining a uniform chip thickness, lessening the rubbing action, increasing cutter life, and giving more pieces per hour, which in the final analysis is the primary objective of using carbide-tipped tools. Fig. 15 shows a cast-steel part milled with the setup shown in Fig. 14.

Elimination of skepticism as to the safety of very narrow carbide-tipped milling cutters, which evolved after a long period of development, has been efficacious in selling this new technique down through the ranks of the manufacturing personnel, and finally to the operator himself.

A case in point is demonstrated in Fig. 16, which shows a milling cutter designed for the operation of slitting a copper casting. On the first tryout, after setting the machine to the proper feed and speed and starting the cut, the chips accumulated so rapidly that they failed to clear the cut, stalling the cutter and crumbling it like so much paper. This fault was corrected and the operation is now paying good dividends. A by-product of this wreck was the fact that the new cutter has proved to be practically shatterproof as compared to high-speed steels where the bodies are hard. Such developments have sold this type of cutter to our production personnel and, in particular, to our safety director, who was also skeptical about the effect of the use of such tools on plant safety.

CONCLUSIONS

The foregoing is a brief description of the application of carbide-tipped cutters and tools in our plant. We have found that if basic fundamentals are carefully analyzed and the system of tool controls, as described, is adhered to, the problem of tool application can be solved.

ACKNOWLEDGMENT

The author wishes to thank the following members of his staff for their assistance in preparing this paper: W. S. Meshew, tool engineer; A. Schako, superintendent of supplies; H. F. Schwinn, superintendent of Tool Division; C. F. Wittlinger, superintendent of process; H. L. Wabler, process follow-up.

On the Art of Cutting Metals

(Continued from page 304)

What does management want today to improve its metal-processing output? It would like correct simple answers to three questions: What tool, what speed, and what feed to use—exactly what Taylor sought to determine in 1881; only today the problem is vastly more complex.

What is being done about the matter? Technical societies, industry, associations, the Army and Navy Ordnance Departments, the War Production Board, and others are each, individually and independently, carrying on investigations and making contributions.

What are the institutions of learning in general doing? As a representative I can answer—not much. Their facilities and available funds are all too limited. Not a half dozen schools are teaching work of this kind.

The technical journals are doing a good job in getting commercial practice and results of research before the public. But this practice, unfortunately, is not always the whole result or the best practice.

METAL-CUTTING RESEARCH SHOULD BE CO-ORDINATED

There seems no better time than this to make a plea for continuous and co-ordinated research in metal cutting, having the combined support of all these agencies. This would provide a trained personnel available for fundamental and applied research. Keeping in mind that science is the simplification of knowledge, it should be the duty of this personnel to study all publications and periodically present to the public reports setting forth the best practice, new developments, and new trends.

This staff, as specialists, could serve industry directly and well. Through it, similar work in colleges and universities and other research agencies could be guided, correlated, and interpreted. Such an organization would have Taylor's blessing; and industry and Government would benefit tremendously in the critical reconversion period.

Industrial

POWER-PLANT OPERATION

By KENNETH R. HODGES

MECHANICAL ENGINEER, DAVENPORT, IOWA. MEMBER A.S.M.E.

DESIGN and operational data for individual power plants have been widely disseminated, but not too much has been made available in the literature on the fundamental principles of operation which apply to all plants, large or small, high or low pressure.

There are two basic reasons why an efficient well-operated power plant is desirable. Management values efficient operation and dependability in a power plant, since these guarantee reduced operating costs. Both management and employees value the peace of mind that comes only when they know their power plant can deliver what is needed, where it is needed, and when it is needed.

In an industrial power plant, operating policies and procedures, maintenance policies and procedures, and plant design all play an important part in the success or failure of the plant in meeting production demands. Each element must be considered, not independently, but in conjunction with the other two. Weakness in one factor may be partially offset by careful planning in the others; but not completely. Correlation of these factors must be carried out for each plant, carefully considering each factor and its relationship to the operation of the plant.

FUNDAMENTALS OF ECONOMICAL PLANT OPERATION

Efficient and economical operation of any plant involves four basic kinds of knowledge—again interrelated. Call them the four "knows:" "Know what;" "know how;" "know when;" "know why." These constitute the foundation upon which depends the success or failure of a plant's operation. Obviously, weakness in any one limits the results obtained from a given plant.

Let us consider these four "knows."

"Know what" seems obvious; know what you are supposed to do. Surely everyone does that. How about knowing what a plant can do, and what the plant is doing? Does every employee in the plant know what he is supposed to do, especially in emergencies? "Know what" now assumes an unexpected magnitude and importance.

"Know how"—just know how to do your job; "experience" is another word, but it has a broader meaning. The problem is to secure this knowledge of "how" without undue expenditure of one's time and the employer's money. We must learn to use the experience of others in enriching our own.

"Know when"—that is obvious, know when to do a given job. Experience covers that. Why mention it at all? Know when is important because it is not experience but judgment that is involved. Know when to make repairs, when to change operating procedure, when to use and when not to use equipment on a given job.

"Know why"—if a man knows what to do, how to do it, and when, surely that is all he needs. Why do we need to know why? There are three main reasons: (1) To know why a given piece of equipment performs as it does is vital to understanding "what," "how," and "when" in operation. (2) To know why equipment does not operate as it should is vital to intelligent corrective action. (3) To know why is essential to keep one from following blindly the easiest way or the traditional way of operating a plant.

APPLYING THE FOUR "KNOWS"

Let us elaborate on these four "knows." They are essential in design, operation, and maintenance.

Starting with the "know what" principle, it is essential to have a definite assignment of duties; be sure each employee knows what he is expected to do and what his responsibilities are; that each employee knows to whom he is responsible as well as for what. Then everyone concerned with the operation of the plant must know what the limitations of the plant's equipment are; in other words, what good performance is and what the plant can do.

Let's consider knowing what a plant is doing. This "know what" must be based on facts, not guesswork. This means that every plant must maintain a record of day-to-day operation on which periodic summaries can be based. To accomplish this it is necessary to know what the plant produces; what labor and materials are used for this production; and how efficient is this production.

For most plants, such items as plant efficiency and production should be determined daily—the others weekly or monthly. Here each plant must write its own prescription. How about justifying all this work? Keeping records costs money.

Records are the essence of efficient operation, not an end in themselves, but only the beginning, because records show everyone concerned what a plant is doing and forcefully bring to the management's attention the need and value of efficient operation.

Records serve another function, they are an important part of the history of a plant's operation. Management not only knows what its plant is doing now, but what it has done in the past, and, when correlated with manufacturing activities and plans, what to expect in the future. Records show whether or not it takes a pound of steam to produce a pound of nuts, or bolts, or screws in department "Z," or whether it now requires two pounds; if the latter is the case there are some bolts, nuts, or screws loose or missing. These must be found and replaced or a plant manager will be missing.

Records demand meters, controls, often scales, and always the necessary work for maintenance. Far too many of us are afraid of anything for which we have to spend money, but remember one thing in the case of meters: Gas, water, and electricity are purchased and paid for on meter readings.

If metering is good business, nay, essential for utilities, why is it any different for an industrial plant? An industrial power plant actually is a utility. The production departments buy its services, but they do not have the faintest idea whether or not they secure their money's worth unless records are kept.

Records, meters, and controls determine what a plant does,

how it does it, and believe it or not, how efficiently the plant operates. Employees are human; if management does not know whether or not a plant operates efficiently, the operators will take the easy way out. That is why our preventable fuel waste is so high; not total waste, remember, our preventable waste.

As stated previously, records are not an end, only the means to an end. Once we have a record of plant performance, we must use that record to gain our end, which is efficient operation. Every plant has a maximum possible efficiency fixed by the design and type of its equipment that the plant cannot exceed. A well-operated plant will come close to this maximum efficiency. Once a manager has such a plant, he will never go back to running his plant so as to just "get by." Have we justified a reasonable expenditure for records?

"Know how" is experience—experience of others as well as our own. We can learn by reading, listening, and talking to men who know; all these add to one's know how. An old proverb says, "Experience is our best teacher." True, but remember that our own experience was expensive in time and, in many cases, our employer's money. Use other's experience for all it is worth, secure and study every good book and article available, and apply what is studied. Today's theory, if good, is tomorrow's practice. "Know how" is valuable; do not overlook any part of it.

"Know when," many say, is experience, just a different wording; no, it is much more. Experience is a part, but only a smal lpart; "know when" is judgment. One may know what to do, but if he doesn't do it when it should be done, he will have failed in his job.

It requires judgment to know when repairs are advisable, when a change in operating procedure is indicated, when an employee can handle a more responsible job; these are only a few of the items involved. Judgment is acquired, not by reading, not by listening, but by exercising and developing what one has. Some people seem to lack any semblance of judgment; they are unfortunate. We can develop our judgment by keeping a constant check on our everyday decisions. Remember, if we don't try to use good judgment in our everyday life, how can we expect to progress to a better job, or even perform adequately the one we have?

Responsibility and judgment have much in common; however, they are not synonymous. Responsibility is given or secured from others. Judgment—"know when"—is what one must possess to be able to be responsible. One cannot long retain responsibility without good judgment in the exercise of that responsibility.

"Know how" obviously involves the actual operation of a plant as does "know when." Let us, therefore, consider them together; they are very nearly inseparable. We must know how to operate equipment and when to repair it; also what equipment to use in a given situation, and when to make a change. All these are items that must be determined for each plant. I can suggest, but the individual must do the job.

Here are my suggestions: Most equipment manufacturers have instruction sheets or pamphlets covering the operation and maintenance of their equipment. Some of these instructions are excellent; some, not so good. Secure and use these instructions because they tell how better than I can. When equipment is purchased, secure the manufacturer's instructions, see that the operators familiarize themselves with the instructions, and follow them. This is "know how" of others—use it, review it, make it a part of one's knowledge.

"Know when" on repairs is simple; "when" is before we have to. Breakdowns should be anticipated, corrective action taken, and we never have to make repairs. They are made before trouble occurs. A well-operated plant will come close to this ideal condition. It will have a maintenance schedule to insure that all equipment is checked and repaired regularly so that it is always in operating condition. Simple, isn't it? Yet, how many plants continue to run until something breaks, then patch things up any way they can until another break. A plant run that way, with one bad break after another, eventually becomes bankrupt.

A forced shutdown in an industrial power plant costs real money; every man, every machine dependent on that plant sits idle until repairs are made. Figure what this costs a plant. Roughly, it is the machine-hour rate of the idle machines, times the hours lost, plus the cost of emergency repairs, plus the cost of any spoiled work. Adds up rapidly, doesn't it? Preventive maintenance—repairs when they should be made—pays excellent dividends.

"Know when" on operating conditions is different. That is where one's own judgment comes into play. I can only stress that here, too, "when" is before one has to. You run your plant; don't let it run you. Be in control of the situation at all times. (Don't get caught; it's embarrassing and dangerous.)

"Know why" is, in my opinion, the most important of the four "knows." That seems strange. If we know what we are doing, how, and when, surely that is enough. Perhaps it is, if one is shoveling rock or digging holes. But three "knows" are far from enough if one is expected to operate a plant or even a small part of one. Unless one understands why, he is handicapped; anything out of the normal stops him cold. When we know why, we can determine the corrective action needed. Knowing the why of things permits intelligent action in emergencies. Good operation means that "know why" is considered, emergency action planned, and the plant personnel drilled in it.

Asking and finding out why is the only reason we have progress. Asking why has given us power plants with boiler efficiencies of nearly 90 per cent. Ask: "why?"

MANAGEMENT'S FUNCTION

It is the function of management to decide whether or not a plant will have records, a maintenance schedule, an efficient, competent operating force, and adequate equipment. Management must demand "*Know what, how, when, and why.*" Management must also furnish the multitude of items required in a plant's operation. Management determines policy, and good management follows through and sees that its policies are carried out.

What policies are necessary for efficient plant operation? First, the plant must be staffed by personnel who know their business. There must be a supervisor who knows what his plant can do and does; who knows how to operate, when work is needed, where; and lastly, one who is intensely curious as to the why of things; "why" always. Why do we? Why can't we? Why don't we? This supervisor must have better than average intelligence and the basic knowledge to understand why equipment performs as it does. Finally, he must be able to pass this knowledge on to his subordinates and increase their know how. What one man knows does not benefit a plant unless that man is always present. Actually, he is absent more hours than he is present. It is when each employee understands his job and the job of his immediate superior that a plant can function with the maximum efficiency.

In addition to hiring good men initially, a plant must retain these men. I have often heard the remark, "Work in that dirty hole? Not me!" A well-run plant will not be a "dirty hole." This plant will be clean and well painted, have good locker and washroom facilities. It will be a good place to work. Management must pay operators not as little as they can, but in accordance with the responsibility the operators must assume. When

employees through more efficient operation lower costs, give them a raise, let them know their efforts are appreciated. In power-plant operation, top management either pays for efficient operation or through the nose for inefficient operation.

ADEQUATE EQUIPMENT ESSENTIAL

A plant must have equipment that is adequate to meet its needs. Plants do not need the latest gadgets, but equipment that will perform the job at hand efficiently. Much can be done by careful scheduling of plant operation to make the equipment adequate. Watch a plant's peak load, watch its minimum load, keep these as near the average load as practical. A uniform load should give ideal operating conditions. We know that such a condition seldom exists in industrial practice, but scheduling and planning will improve a plant's loading and pay dividends.

Furthermore, a plant must maintain its equipment so that such equipment may meet its requirements at all times. It is immaterial how badly new equipment is needed; a plant operates today on what it has in operating condition, not what it should have. An industrial plant, like a utility, must be able to deliver what is needed, where it is needed, and when it is needed. I have said before and will say it again, "Preventive maintenance is the only kind for a power plant to use." Repairs after a breakdown are not maintenance, but rather are poor judgment on someone's part. These emergency repairs are several times as expensive as the same repair would be if made on a maintenance schedule. Establish a schedule, follow it, and the plant's troubles will markedly decrease.

PAINT AND LIGHT PROMOTE EFFICIENCY

Paint is an excellent example of "preventive maintenance." We are all familiar with the use of paint to preserve the outside of a building, but inside is a very different story. In money value, the equipment inside a shop is worth many times the exterior surfaces we know must be painted. Paint, or whitewash if nothing better, is the best assurance that the equipment in a plant receives the attention it requires. If we have dirt and grime everywhere we look, how are we going to keep that dirt out of bearings? If we don't keep this dirt out, how long will it be before we have an expensive repair bill?

Men require light to work effectively. We all know that a well-painted plant is an infinitely better-lighted plant. With the same lights and fixtures a plant can, in most cases, show a saving on its light bill and still have adequate light in the plant. Another saving, an intangible one, is that in a well-painted plant, leaks, whether water, steam, oil, or flue gases, stick out like the proverbial "sore thumb." They are repaired because they are so evident, and because they "dirty up" a clean plant.

A well-painted plant pays in another intangible way; employee morale. Good men take pride in their work and are proud of the place in which they work. A clean, orderly, well-painted plant is one to be proud of, not only by the men who work in it, but by the management as well. One of life's brightest moments is when one knows that the plant in which he works is rated the best in his community, no matter what his position—president of the company or the lowliest laborer.

We have said a plant has a maximum operating efficiency determined by its design that it cannot exceed. A well-operated plant can and must come close to this maximum figure. Management can and must do one thing, i.e., study what the plant does, how it is done and why, and so gain and maintain efficient operation. Constant vigilance is the price of life and efficiency. While making this study, watch one more point. Drudgery is expensive and inefficient; eliminate it every place possible. Pay men to operate not wheel coal or ashes or saw wood.

CORRELATION OF PLANT DESIGN AND OPERATION

A discussion on power-plant operation is incomplete without some mention of plant design. Engineers as a whole understand design principles, but many do not understand the correlation of design and operation. Design may be mechanically sound, but impractical and hazardous from the operators' point of view. Remember, valve, control, pump, every piece of mechanical equipment requires attention, lubrication, maintenance, and operation. If a man has to use a ladder to open a valve or grease a machine, the tendency is simply to forget the thing exists. If a man is in danger of getting burned or injured, he will forget even faster.

When a machine requires adjustment, can the adjustments be made in place or does that part of the plant literally have to be dismantled? This means just one thing—consider the plant personnel when making your plans; design so that controls are used for control, not profanity; so that equipment can and will be serviced when needed. In short, design so that it is possible to have a clean efficient plant. One big dividend is that we also have a safe plant. Safety engineers tell us this alone is worth more than the cost of catwalks and extra floor space required.

When it becomes necessary to modify an existing plant or build a new one be sure that operation and maintenance are considered. A plant is built once but operated for many years. Failure to correlate design and operation means operating and maintenance problems as long as the plant is used.

All the foregoing will apply to any industrial plant—call them the ABC's of plant operation. No one can tell how an individual plant should be operated, but can only suggest. Equipment is inanimate; a plant can have the best equipment and the best controls, but unless the personnel has the brains to make its individual members function correctly, they are useless. Efficient economical plant operation requires clear thinking and constant vigilance by top management, plant supervision, and plant operators. The tools required are simple plain common sense—just apply the four knows—"*What, How, When,* and *Why*"—from top management down. Apply these four to design, operation, and maintenance, and problems will solve themselves.

Rear-Engine Automobile

POSSIBILITY of producing, by 1947 or whenever public demand develops, a rear-engine passenger car possessing the economy of small models and the roominess of large vehicles was reported to the Society of Automotive Engineers Annual Meeting, held in Detroit, Mich., in January by William B. Stout, of Consolidated-Vultee Aircraft Corporation and Graham-Paige Motors Corporation, Dearborn, Mich.

Mr. Stout told the Passenger Car Body Session that such a car could have interior floor space six and one-half feet wide and eleven and one-half feet long, accommodating comfortable lounging chairs, couch or bed, and table. He proposed that the body be made of glass or equivalent fiber plastic with an impact strength several times that of steel. He suggested such changes as removable engines equipped with sleeve, slide, or cuff valves and improved connecting rods, bearings, and crankshafts. Better heat and sound insulation, greater economy, lighter weight, and lower costs all are possible with the use of new techniques and materials, Mr. Stout asserted.

Operation of an experimental car for 200,000 miles in eight years, Mr. Stout added, has demonstrated the practicality and the advantages of rear-mounting of engines and of suspension which puts the vehicle's center of gravity below the level of support.

Development of
ROCKET AMMUNITION

By MAJOR H. G. JONES, JR., U.S.A.

OFFICE OF CHIEF OF ORDNANCE, WASHINGTON, D. C.

IN connection with rocket developments, probably the first question that occurs to the average individual is why do the Army and Navy require a new weapon such as a rocket when so many types of ordnance are already available? The answer is that its characteristic lack of recoil opens a broad range of military applications for the rocket where heavy weapons could not formerly be used.

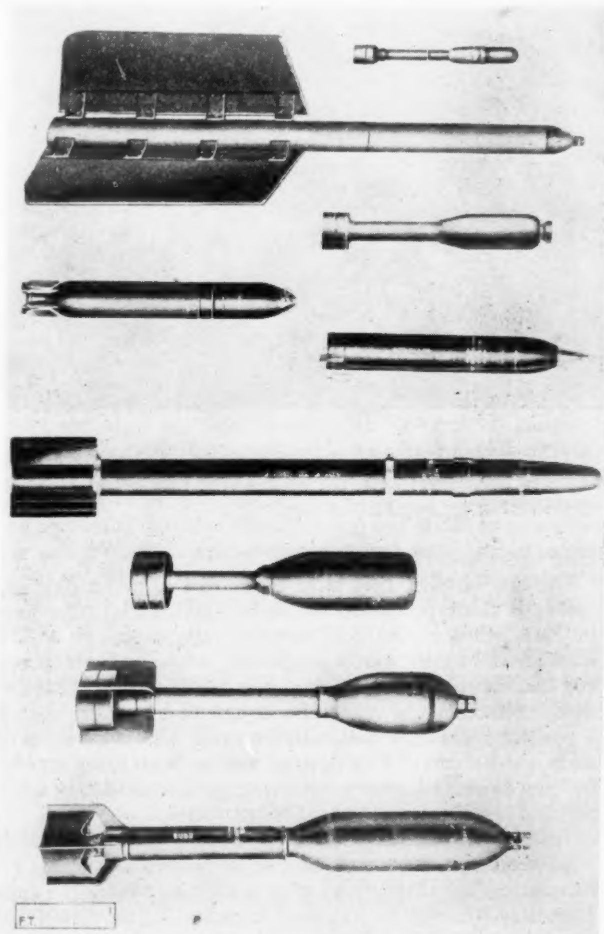
A SUPPLEMENT TO ARTILLERY

A weapon without recoil can be mounted on firing platforms of light construction which could not withstand the force of recoil encountered in artillery weapons. This has permitted rockets of large caliber to be mounted on such vehicles as ducks (DUKW), PT boats, jeeps, various sizes of standard trucks, and on fighter aircraft. The fire power of these vehicles was tremendously increased as they could not normally carry any heavier armament than machine guns. The rocket is a supplement to artillery.

A rocket operates on a simple reaction principle, that is, Newton's third law of motion—to every action there is an equal and opposite reaction. The action is created by the burning of a suitable fuel and the ejection under pressure of the gaseous products at high velocity.

The rocket motor therefore does not obtain its thrust by the exhaust gas pushing on the surrounding air. Actually the atmospheric pressure is a back pressure to the escaping gas, analogous to the back pressure in a turbine discharging into a secondary stage. As the external pressure decreases, the thrust will increase. In other words, a rocket motor would operate more efficiently in a vacuum. The efficiency of a rocket is less than the efficiency of a gun, although both use energy from the burning of a fuel to propel the projectile. However, since there are functions which the rocket will perform that the gun cannot, efficiency is not of primary importance.

A measure of rocket performance is obtained from the momentum equation of $mv = MV$. This will show the importance of careful design and engineering, with the object of holding down the weight in order to obtain as high a velocity as possible with a given weight of fuel.



REPRESENTATIVE TYPES OF ROCKETS

FEATURES OF MILITARY ROCKETS

The components of the ordinary rocket used as a military weapon are the fuze, the shell or head, the motor chamber, the nozzle, the propellant, and a means of stabilizing the projectile. Fuzes used for rockets are essentially similar to artillery fuzes. The principal difference is in the design of the safety features, as most rockets have accelerations of a much lower order than shells. For unrotated rockets, a propeller-arming fuze is generally used. This type of fuze is similar to bomb fuzes and requires a certain distance of air travel to spin the propeller before the fuze can arm. For rotating rockets, centrifugal elements are used which require that the rocket shall spin above a predetermined minimum number of revolutions per minute before the fuze can arm. These features make the complete rounds safe for handling.

The shell or head is the container for the pay load desired; this may be high-explosive, chemical, or incendiary. In practically all rockets, the shell is fastened in front of the rocket motor. The only rocket known to the author in which the motor is in front, so that it may be viewed as pulling the shell along instead of pushing it, is the German 15-cm rocket.

The motor consists of a combustion chamber in which the burning of fuel takes place, and a nozzle or nozzles through which the gases exhaust. The nozzle axis may be parallel to the rocket axis, in which case the rocket would be of the un-

Address presented at a meeting of the Washington Section, Washington, D. C., October 11, 1945, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

THE MUTIPLE ROCKET LAUNCHER T66 IS SHOWN BEING LOADED WITH 4.5 IN. M16 ROCKETS

(The loading is being done by "B" Battery of the 282nd Field Artillery Battalion, VIII Corps, First Army. A demonstration was held for all division artillery officers on May 8, 1945, at Wolfsham, Germany.)

rotated or fin-stabilized type, or if the nozzle axes are at an angle to the rocket axis, the rocket will rotate and be of the rotational or spin-stabilized type.

FUEL FOR PROPELLING THE ROCKET

The first element that must be known in the design of a rocket is the type of fuel or propellant that is to be used. In 1941, when rocket development really began on a large scale for the recent war, a propellant, whose basic properties and characteristics were known, was needed as quickly as possible. Selection was made of a double-base powder, that is, a powder containing nitrocellulose and nitroglycerin as its main constituents. This powder was far from being an ideal fuel and as a result, many engineering problems had to be solved before a successful rocket could be completed.

This powder could be extruded in stick form with any desired geometric shape and with or without longitudinal perforations. The shape of the grain and its dimensions are of the utmost importance for the proper control of the area of the burning surface. Rigid inspection was required to insure that grains met all physical and chemical requirements and were without flaws. Some types were x-rayed as an additional precaution to locate internal flaws which could not be detected by visual means.

A solid fuel must contain all of the oxygen necessary for combustion as the free volume in the motor is much too small to contain sufficient oxygen to support burning.

An igniter must be designed which will fit into the motor chamber and which will ignite the propellant evenly, rapidly, but without shock which may tend to shatter the powder grain. The igniter generally contains an electric match which will function on low voltage, surrounded with black powder. After it has been ignited, the propellant will, in a properly designed chamber, burn smoothly until completely consumed. The burning will cause a very rapid pressure increase until equilibrium conditions are reached and then will either increase or decrease, depending upon whether the grain is progressive or regressive in burning. The pressure will drop quickly after completion of burning. The ideal condition is to have a neutral-burning grain, which will allow the pressure to remain constant from beginning to end; in other words, the average pressure will be equal to the maximum pressure. This is seldom possible because of end-burning.

The strength of the motor chamber must be based upon the maximum pressure that will be attained, but the thrust or power obtained from the rocket motor is dependent upon the average pressure. Hence it is obvious that for design purposes, lightweight of metal parts, and efficiency, these two pressures should be equal.

The rate of burning of the solid propellant, or double-base powder called "ballistite," which has been used in all service rockets, is dependent upon the temperature of the grain before the time of ignition. A change in the rate of burning means a change in the pressure. This is expressed by the exponential equation $r = CP^n$, where n is less than unity and will vary with each different propellant composition. The combustion period is dependent upon the rate of burning and on the web thickness of the grain. The combustion time of the rockets being considered here is generally less than 2 sec and in some cases, less than 0.2 sec. The burning distance will vary directly with the burning time. For applications such as the well-known bazooka rocket, it is obvious that a very short burning distance is one of the main considerations as the launcher from which this rocket is fired is shoulder-held. For applications where the firing is performed by remote control, or where protection from the blast of the rocket gases can be obtained, a longer burning distance can be tolerated.

METALLURGY AN IMPORTANT CONSIDERATION

It has been mentioned that the design of the motor chamber for strength is dependent upon the maximum pressure. Since the maximum pressure increases with an increase in tempera-

ture, the design pressure will be the maximum pressure obtained at the maximum temperature encountered, plus an adequate factor of safety. Many of the early difficulties in motor design resulted from not being able to obtain steels with sufficiently high tensile properties. The critical shortage of steel in the early part of the war made it necessary to use a straight carbon steel, in most cases 1025. Seamless steel tubing was critically short, and welded tubing was used with some success.

In order to hold the weight down, which is a very important factor in rocket design, the steel tubing was cold-drawn to give physical properties of approximately 80,000 psi yield strength, and was stress-relieved to obtain elongations of not less than 10 per cent.

Later in the program alloy steels became available and were used extensively. These steels were generally of the National Emergency composition with the greatest usage in the NE8630 to 8640 types, electric-furnace grade. These steels responded well to heat-treatment and, in addition, were satisfactory from the machinability standpoint. In the case of the 4.5-in. rocket, where a high-strength motor chamber was required, the heat-treating process involved to obtain a minimum yield of 135,000 psi and a minimum elongation of 8 per cent presented several interesting problems. The wall thickness was very thin, and the requirement for concentricity was close; practically no distortion or ovality could be permitted.

The first experiments showed that no difficulty could be expected in obtaining the desired physical properties, but the distortion problem was serious. Pilot quantities were heated in pit-type furnaces and were oil-quenched. It was found that approximately 50 per cent would not meet the concentricity gage and would have to be straightened, if possible, or scrapped. The hot-salt-quench method was then tried and considerable improvement resulted. The final method consisted of a preheat, then high heat (1575 F) in salt, hot-salt quench, and then a draw, followed by a hot-water rinse. This procedure gave excellent results, and the salt prevented scaling so a clean tube was obtained without further operations. This system was conveyerized and automatic in operation. Machining of the threads was generally performed after heat-treatment, and all methods, such as tapping with a collapsible tap, milling, and grinding, were used in mass production.

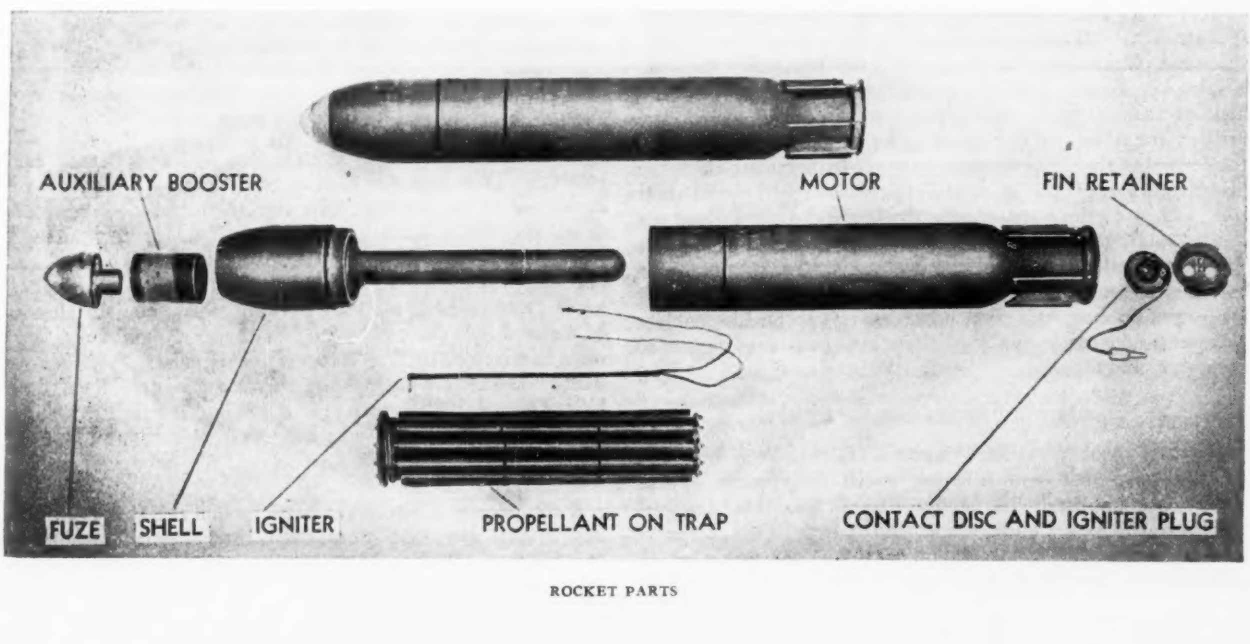
The burning of the fuel in the chamber imparts considerable heat to the walls—the temperature rise of the steel walls being dependent upon the temperature of combustion and the time of burning. The temperature of the gases is in the neighborhood of 2400 C so that this problem becomes increasingly important as the burning time increases. Very little information was found to be available on the physical properties of steel at elevated temperatures, so that numerous firing tests had to be conducted to check the safety of the motors. For burning times not longer than 1 sec, the normal cold strength was satisfactory for design purposes.

FABRICATING METHODS

Practically all motors that were placed in mass production had V-type threads for fastening the chamber to the head, and in some cases for fastening the nozzle to the chamber. As mentioned previously, the nozzle and the chamber together constitute the motor. Since the thread section is subject to the radial stresses created by the pressure, and also to the radial component from the V-threads as the head and chamber try to separate, the wall thickness at this point must be greater than the chamber wall. This requires that the thread section must be carefully designed.

Two courses of procedure are available; make the motor wall to the desired thickness and then upset the end for the thread section, or use a tube with the desired thickness for the thread section and machine off the wall below the thread section. This must be done to keep the chamber weight to a minimum. Both of these methods were used in production. The equipment and materials that could be obtained quickly chiefly influenced the method selected. One other method which might have been applied was to use buttress-type threads instead of standard V-threads. Pilot models were constructed and tested which proved that this type of thread was satisfactory without increasing the thickness of chamber wall at the thread section. However, for mass production, the manufacturers desired to avoid using processes with which they had had little experience.

The use of the buttress-type thread should see additional applications in the future for rockets and other types of pressure vessels. All motors were hydrostatically tested 100 per cent during production.



ROCKET PARTS

NOZZLE-DESIGN CONSIDERATIONS

The exit area through which the burning gases pass is the orifice or nozzle. The nozzle may be single, that is, one restriction through which all the gas must pass, or multiple nozzles may be used where part of the gases pass through each nozzle. Finned-type rockets use both single and multiple nozzles, while rotating rockets use only the multiple type.

We will consider the fin-stabilized rocket first as that is the type which allows the greatest choice of nozzle design. The single nozzle is obviously the cheapest type to manufacture It can be made as an integral part of the chamber by necking down one end, or it may be made separately and then welded into one end of the chamber. The Army 4.5-in. M8 rocket is an example of the first type, and the British antiaircraft rocket is an example of the second type.

The single-nozzle rocket received considerable study in both the research and manufacturing phases. The problem was to obtain accuracy, and that meant the center of thrust had to pass as nearly as possible through the center of gravity of the rocket. This placed a premium upon the alignment of the nozzle. Many elaborate gages were designed to measure the amount of misalignment, and research studies on the firing of many hundreds of rockets indicated the tolerance that could be permitted to make the rocket tactically satisfactory. The rocket is not as accurate as a gun and is generally employed on area targets, but the dispersion must be held within known limits, and these limits must be acceptable to the using services.

Multiple nozzles, that is, several small nozzles, can be used in place of one large nozzle. The production of this type is more expensive than the single nozzle but the resulting misalignment is less. The alignment of each nozzle will not be perfect but since it will be more or less random from each nozzle, the composite thrust is fairly well aligned. Certain types of aircraft rockets are made with this construction and give very acceptable dispersion patterns when fired.

For rotating rockets, that is, rockets which are stabilized by spinning like an artillery shell, multiple nozzles are used. These nozzles have their axis offset to the longitudinal axis of the rocket so as to impart a spiral motion to the emergent gases and a resultant rotational thrust. This type of rocket is very satisfactory as a ground-to-ground rocket as good accuracy can be obtained. An example of this type is the 4.5-in. M16 Army rocket.

Several interesting methods of manufacturing multiple nozzles were found. A large quantity were made by taking a disk of steel of good machining quality, such as 1335, and drilling the holes, using a fixture that would hold the disk at the desired angle. When accurately made fixtures were built, the manufacturing operation was a fairly straightforward drill job. Other nozzles were made by drilling a straight hole at the desired angle through a plate and then inserting the nozzles. The individual nozzles could be made at a rapid rate on automatic screw machines. The nozzles were held in place by staking or brazing. Gaging, however, was a difficult problem as several concentricities and alignments had to be measured accurately and rapidly.

STABILIZING VARIOUS TYPES OF ROCKETS

Unrotated rockets require some form of fins to keep the round moving nose first and without excessive yawing. These rockets are stabilized like bombs. Large fixed fins, fastened rigidly to the rocket body, are generally used. One exception to this was the folding fins used on the 4.5-in. M8 rocket which allowed this round to be fired from a tube not much larger in diameter than the rocket itself. The fins were caused to open in the extended position upon leaving the tube by the force of acceleration. In the design of fins, full advantage was taken of aerodynamic theory. Much valuable data were secured from wind-tunnel tests. The final proof of the design is always in the firing, and many hundreds of rounds were expended to check the results. The fixed fins appear to be best for firing from aircraft

To stabilize a rocket by rotation, it is necessary to spin the round fast enough for it to become gyroscopically stable. This rate of spin is quite high and is in proportion to the velocity of the rocket. In this effect, the rocket behaves the same as an artillery shell. The rotation is obtained, as previously described, by placing the nozzles at an angle to the axis of the round.

ROCKET LAUNCHERS

Many types of launchers have been constructed for firing rockets. Because of the lack of recoil, the launchers can be more simply and less expensively built than guns. For finned rockets, the launcher generally consists of a simple rail framework with the necessary firing contacts. For folding-fin rockets, a tube is used instead of rails. The rotating rocket can be launched either from rails or from a tube; in fact, just a trough may be used.

The launchers are equipped with electrical firing devices so that the rockets may be fired from a remote position to avoid danger from the blast. The rockets can be fired in rapid succession; this is known as ripple fire. With multiple-tube launchers, it is possible to fire a large quantity of rockets in a very short period of time. This then gives the Army and Navy great fire power.

TEST INSTRUMENTS IMPORTANT FACTOR IN ROCKET DEVELOPMENT

None of the advancement in rocket design would have been possible without an equivalent advance in test instruments. A large percentage of the total time spent in developing rockets was devoted to the problem of providing instruments to measure the various phenomena which occur. Cameras to take clear pictures at a rate of more than 1000 frames per sec, and electronic gages to measure pressures over 20,000 psi and fluctuation in pressures, occurring in a time interval of 1 millisecond, were required. Whenever we speak of rockets for the future, one question must be answered—do we have available the instruments necessary to furnish the data? This must be a continuing study.

GERMAN V-2 ROCKET

A few facts concerning the German V-2 rocket may be of interest. This was one of the most amazing weapons to be developed during the war. Its velocity surpassed the velocity of all previously known projectiles. The length was 46 ft, diameter $5^1/_2$ ft, and the weight, loaded with fuel ready for the take-off, was 27,000 lb. Liquid fuel was used, as this type is much more suitable for long burning times, and the fuel can be metered into the combustion chamber. Alcohol and liquid oxygen were the fuels. To operate the pumps, hydrogen peroxide and calcium permanganate were mixed to form superheated steam. The velocity, after the burning time of approximately 1 min, was 5000 fps, over 3000 mph. The range used was 200 miles. This is a weapon that was produced and used —against the Allies.

A comparison between the bazooka and the V-2, both products of this war, may be an indication of what another war could bring. Help us keep our developments so far advanced that another war cannot happen.

The MECHANICS *of* HUMAN MUSCLES

By HOWARD W. HAGGARD

DIRECTOR, LABORATORY OF APPLIED PHYSIOLOGY, YALE UNIVERSITY

THE physiology that is dealt with in this paper, namely, the gross mechanics of muscles, is among physiologists distinctly old-fashioned. It had its vogue in the eighties and nineties of the last century when the Weber brothers and others attracted much attention with their ingenious devices for studying muscular movement and muscular efficiency in men and even in race horses, and when Mosso devised his ergometer. It was 35 or 40 years ago that Amar recapitulated these researches and made some applications to simple industrial procedures such as lifting weights, climbing stairs, hand filing, and the like. In so far as I can determine, his book "The Human Motor" attracted only mild interest among physiologists and little, if any, among engineers. There were reasons for lack of interest in both directions which are pertinent to what will be discussed.

EARLY LABORATORY WORK

Physiological studies, in so far as muscles were concerned, had moved beyond gross mechanics and had been retired to the laboratory to investigate in refined measurement the physicochemical and thermodynamic changes incident to the contractile process. From such investigations much was found out as to occurrences within the muscle: Phosphocreatine was broken down during contraction and re-formed during relaxation; the energy of reformation was derived from the conversion to lactic acid of glycogen; the chemical changes during relaxation consumed oxygen and liberated heat.

The features in this complicated process which caught and held engineering attention were the need for phosphates and the formation of lactic acid, and both only in their bearing on fatigue. The practical but dubious conclusions were that the addition of phosphates to the diet should relieve fatigue and that fatigue was due to the accumulation of lactic acid. The transfer of physiological knowledge to industrial theories and practices is not always felicitous—a fact that I have repeatedly emphasized. It was especially unfelicitous in the enthusiastic transfer of the acid-accumulation theory of fatigue to explain a progressively diminished industrial performance called fatigue.

The fatigue the physiologist was dealing with and talking of was of the sort seen in the athlete who uses large masses of muscles at a maximum rate, a rate greater than the sustained capabilities of his circulation, who exercises so strenuously that his muscles need oxygen at a greater rate than his blood can bring it and who staggers and collapses at the finish line of the race. In a limited experience in industry, I have seen few workers who approached their tasks with this spirit or who gave of themselves to their work so generously. It is true that the worker's capacity to do work, or at least the rate of doing it, may diminish in the course of doing work just as does the athlete's abilities during his strenuous exertion, but it does not follow in science that phenomena which have comparable results invariably have similar origins. The so-called fatigue of the industrial worker indicated as progressively diminished performance and a feeling of tiredness is not the same as the fatigue of the athlete, and the attempt to explain it and remedy it by practices carried over from strenuous athletics leads only to erroneous explanations and wrong solutions.

At this point, I wish to re-emphasize the fact that industry has not utilized the vast amount of physiological information which could be given industrial significance. Furthermore, physiological study has only in isolated instances been designed with industrial aims in view. The discoveries of physiology have had their aims and utilizations not for the improvement of the performance of the well man in the field of industry but for the benefit of the ill man in bed. Physiology has been medical in intent and in application. It is usually a branch of medical study. The main reasons stem from an axiom in my field; it is: An experiment cannot be carried bleeding from the laboratory to the bedside. Similarly, it cannot be carried to the factory. It must be interpreted in its field of application.

For the ill man there is for application the necessary intermediary in the physician. He knows the ill man, he knows medicine, and he knows physiology. There is no similar regular training of intermediaries for industry to make application toward the increase of productivity and diminution of strain of the industrial worker, that is, a man who knows the well man in the environment of industry, who knows industry, and who also knows physiology. Because of the lack of such an intermediary, the successful display of physiology in industry has been primarily in the direction of contending with the hazards of health, essentially medical.

There have been notable investigations in this direction: I cite those on the cause and prevention of caisson disease inspired largely by Dr. Haldane; our own investigations on carbon-monoxide poisoning as an engineering assignment in the development of standards of ventilation for the Holland tunnel; the work that has been done on industrial toxicology of solvents, gases, and dusts; and the investigations that have been made on oxygen deprivation, gravitation, and centrifugal forces in aviation. All such investigations deal with hazards; few indeed deal with the improvement of performance or the relief of strain for men for whom the hazards have been brought under control.

The last fact is my justification for dealing here with an aspect of physiology which, in so far as discovery and even physiological interest are concerned, is out of vogue by two or three decades. There are signs, however, of an awakening interest in the fact that the engineer in industry, whether he faces the fact or not, is dealing with physiological problems and is paying for physiological operations.

ELEMENTARY FACTS OF BIOLOGY APPLIED TO MUSCULAR ACTIVITY

Now in turning to the specific topic of this paper, namely,

Contributed by the Biomechanics Committee of the Aviation Division and presented at the Annual Meeting, New York, N. Y., Nov. 26–29, 1945, of The American Society of Mechanical Engineers.

that of muscles, some facts concerning preliminary elementary biology should be mentioned. Muscle is one of the tissues of the body. All flesh, that is, all tissue, is made up of cells. A tissue may be defined as a group of cells specialized for some particular function. All cells of all tissues have in common one property, that of energy transformation. The phenomenon of life is inseparably connected with the liberation or the transformation of energy. When the human body ceases to move and no longer liberates heat, it is dead. Every cell of that body during life continually burns carbon or hydrogen, which are the combustible elements of food, and the chemical energy thus liberated is transformed into energy in the form of work and heat and, in some instances, electricity. In the process of specialization to form tissues, most cells of the body have lost the ability to transform chemical energy into energy as movement; this ability has been largely limited to and developed to a high degree in the cells which constitute muscles.

The muscle cells are elongated spindles which possess the ability, when stimulated, to shorten along their long axis and thus through tendinous sheaths about them to pull upon structures to which they are attached. A muscle never pushes, but only pulls. Consequently, muscles attached to the bones, the skeletal muscles, with which I deal exclusively here, must be arranged in antagonistic pairs such as the biceps and the triceps. The biceps pull the forearm inward, flex it, the triceps are needed to pull it back into extension. One muscle always pulls against another.

This antagonistic arrangement is a feature in limiting speed of performance. Muscle is gelatinous, viscous, and force is needed to change its shape. With increase in speed, an increasing portion of the energy expended by a muscle in contracting is diverted to stretching its antagonist and its efficiency for external work is correspondingly diminished. There are thus optimal rates of performance.

Again, a muscle always pulls against its antagonist even during what is called "rest." I use the word rest with quotation marks about it because no absolute rest ever exists during life; only variations in rate of activity. I digress momentarily on this point because in industry the word "rest" has been as badly abused in concept as has fatigue. Thus, as an instance, a girl typing may be expending per hour 140 kilocalories total energy; she then has a rest period, so-called. If she simply sits still, her expenditure will drop by perhaps 20 per cent but if she gets up, walks about and talks, as she usually will, her expenditure rises by some 50 or 100 per cent over that which she had while doing work.

The term "rest period," particularly if it has behind it the conception of getting rid of accumulated waste products in the muscle, is a misnomer. It is not rest but relief from one occupation, with a change to another.

THE MUSCLE MEASURED BY POWER AND HEAT OUTPUT

At rest one muscle always pulls against another; this pull is known as "tonus." No work in the sense of movement is performed but energy is expended in the pull of the muscle, and this energy is liberated as heat. It is this heat which is mainly responsible for keeping the body warm. Tonus during consciousness does not fall below a certain level but it may rise considerably if the heat loss from the body is increased. Thus in cold surroundings, the muscles become stiff; the stiffness is not due to any change in viscosity of the individual muscle but to the increased pull of a pair of antagonists—an increase associated with greater production of heat. The stiffness in movement results from the greater effort which must be made by one of the pair of antagonists in overcoming the increased tension of the other to produce the movement.

In moving, a muscle liberates energy not only as work but as heat and, as would be expected, the heat predominates even in the most efficient muscular action. The efficiency, expressed in terms of total thermal efficiency, is surprisingly high for a machine burning carbonaceous fuel at the low temperature at which the muscle operates. Efficiencies as high as 30 per cent, possibly even higher, may be developed in muscles responsible for common acts, such as walking.

Some 20 years ago my former colleague, Yandell Henderson, and I made a fairly extensive engineering evaluation of the muscular activity of the members of a Yale crew which had won an Olympic race.[1] We duplicated the work on the oar in the water with a measuring pump working against pressure on a modified rowing machine to determine the work performed, and collected, measured, and analyzed the expired air. From these data, as has been done frequently in similar experiments for different occupations, we were able to estimate the power developed and the efficiency of the muscles used. These men, operating at close to racing speeds, that is, for an eight-man shell for $1^1/_4$ miles a speed of 10 to 12 knots, each delivered 0.5 to 0.6 hp. The power output for the entire crew was found to agree with the drawbar pull on the loaded shell at this speed. The total thermal efficiency at which the muscles of these men operated ranged from 21 to 25 per cent.

The problem of the gross mechanics of muscular action has in it one feature of especial prominence and especial importance. It is the fact that the force of the pull of a muscle, and in turn its efficiency, is for any muscle a function of the length to which the muscle is extended. The greater the extension, the greater the pull; as it shortens, the maximum it can pull decreases. In analogy—but remember it is analogy only—a muscle may be thought of as operating on the principle of a toggle lever with the force of the muscle one of lateral expansion and therefore exerted at right angles to the line of pull. When such a lever is fully extended, i.e., the muscle fully extended, the resultant of this force would be high along the line of pull; it would decrease with shortening. On this basis, a long slender muscle would be, for its mass, more efficient than one of equal mass which was short and thick.

MECHANICS OF THE LEG MUSCLE

The particular application, however, that I want to illustrate here has to do with position in relation to efficiency and power of effort. In approaching this point, a brief analysis will be presented of the mechanics of the gastrocnemius group of muscles operating through the Achilles tendon on the foot to rotate it on the ankle joint.[2] This muscle, which makes up most of the calf of the leg, is attached at the top to the lower end of the thigh bone above the knee joint. It operates through the foot as a lever of Class 1. The center of rotation can be readily determined by attaching a small lead disk to the skin near the center and then taking a series of X-ray pictures laterally with the foot in several positions of extension and flexion, Fig. 1. The shadows of the disk and of the joint structure allow calculation of the center and its placement on the surface in relation to the disk.

The length of the lever arms would be the distance from the center to the attachment of the tendon and from the center to the ball of the foot, Fig. 2. In a man of average size the relation of these two measurements would be such that the mechanical advantage of the lever would be of the order of 0.4.

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[1] "The Maximum of Human Power and Its Fuel," *American Journal of Physiology*, vol. 72, 1925, pp. 264–282.

[2] All methods, measurements, and figures given subsequently were made by Dudley Miller of the Laboratory of Applied Physiology, Yale University, and included in a dissertation for the degree of Ph.D. entitled "A Mechanical Analysis of Certain Lever Muscles in Man."

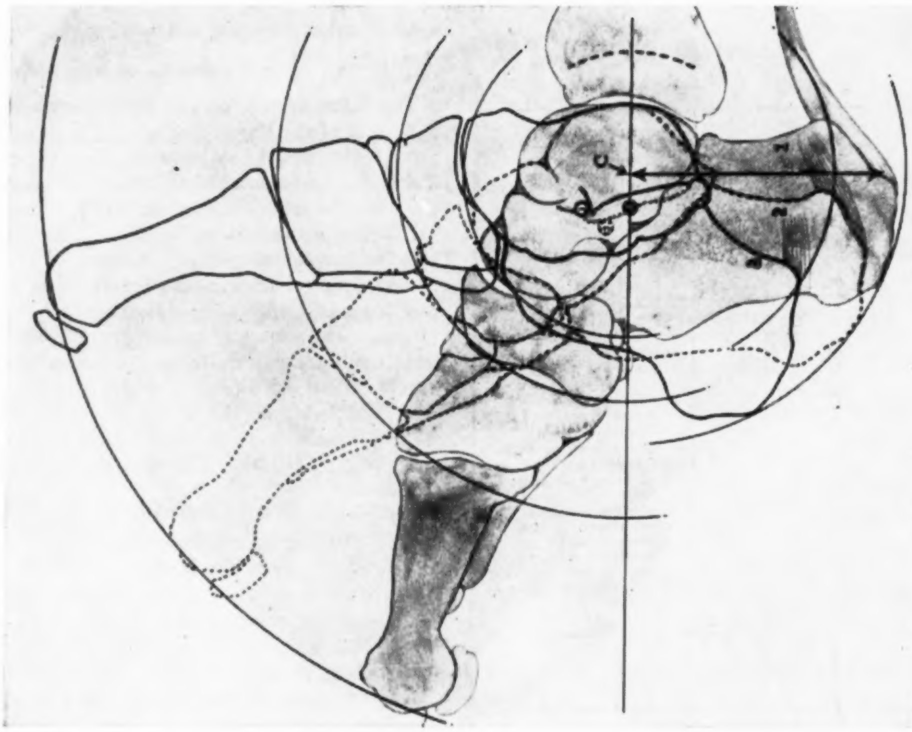

FIG. 1 DETERMINATION OF CENTER OF ROTATION OF ANKLE JOINT FROM TRACINGS MADE FROM X-RAY PICTURES

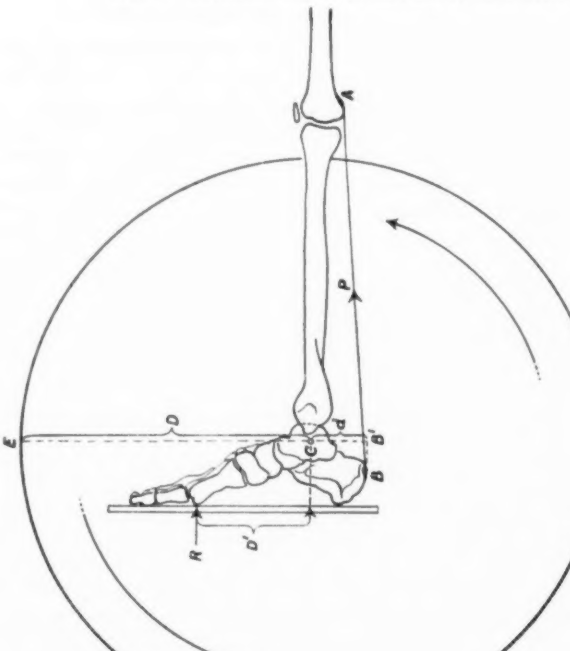

FIG. 2 LEVER SYSTEM OF GASTROCNEMIUS MUSCLE
(The two lever arms d and D' give an advantage of the order of 0.4.)

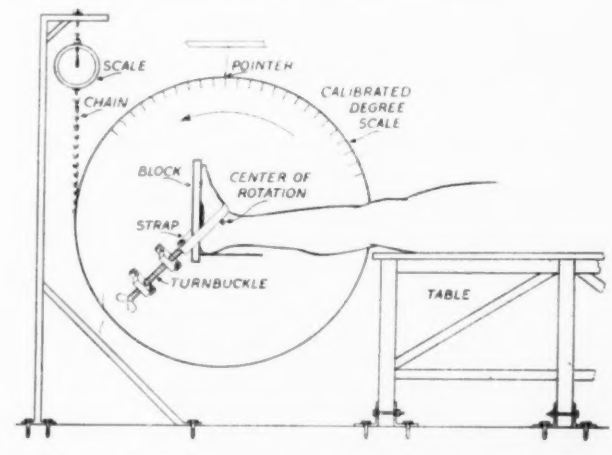

FIG. 3 APPARATUS USED FOR MEASURING PULL OF GASTROCNEMIUS MUSCLE AT VARIOUS DEGREES OF ROTATION OF FOOT

The maximum force that could be exerted by the muscle can be measured by strapping the leg to a plank on which the subject lies with the center of the ankle joint in direct line with the center of a shaft placed at right angles to the line of the leg and carrying a wheel several feet in diameter, Fig. 3. The foot is strapped to a pedal on the shaft and a spring scale attached tangentially to the large wheel by a chain. The purpose of the large wheel is to limit in so far as possible any motion of the foot in moving the scales. With the wheel and pedal in several positions, the foot in corresponding positions of rotation and the muscles at various lengths, the maximum effort to rotate the wheel is made with the foot, and the pull on the scale is recorded. The actual pull of the muscle can then be calculated.

In such observations made on individuals of average size it was found that when the foot was rotated upward to its maximum normal position, namely, an angle of some 106 deg to a line extended beyond the foot parallel with the leg, the pull of the muscle on its tendon was of the order of 900 to 1100 lb, and the force applied at the ball of the foot, therefore, from 360 to

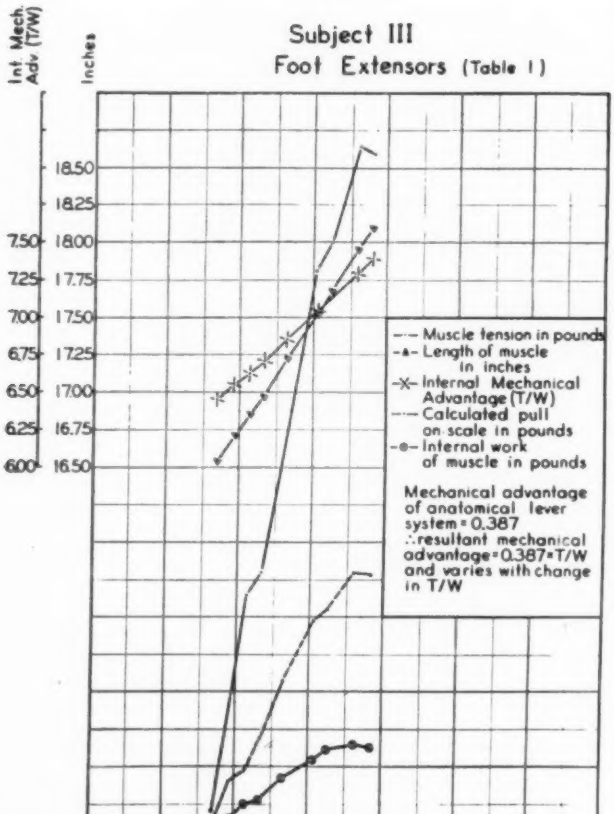

FIG. 4 DATA OBTAINED FROM MEASUREMENTS MADE ON GASTROCNEMIUS MUSCLE

(The pertinent feature here is the decreasing force delivered by the foot, i.e., calculated pull on scales in pounds, in relation to the length of the muscles as determined by the degree of rotation measured as the angle of the foot to a line extended beyond the foot parallel to the leg.)

440 lb. With the foot brought forward an angle of 65 deg to the extended line parallel with the leg, the muscle had shortened some 2 inches and the pull on the tendon had fallen off by some 75 per cent to 275 to 325 lb, and that on the ball of the foot to 110 to 130 lb, as contrasted with 360 to 440 lb. Fig. 4 presents the data obtained from a series of observations on one subject.

Since the subjects used weighed more than 150 lb, they would not have fared well as toe dancers but, more important to them, they would not have worked advantageously in an occupation requiring operation of, say, a heavy treadle if the position were such as to involve marked extension of the foot. The disadvantage would be further accentuated if the subject was seated in a chair of ordinary height and with the lower leg at right angles to the upper. In such a position the attachment of the gastrocnemius muscle at the thigh bone is lowered and the muscle shortened with corresponding decrease in efficiency. Part of the efficiency could be restored in this position by extending the leg and by placing the treadle some distance forward and as nearly horizontal as possible.

THE BICEPS AS A LEVER SYSTEM

The lever system of the foot is such that the diminishing force of the shortening muscle is reflected directly in the force which is applied through the ball of the foot. Quite a different arrangement exists for the biceps muscle in flexing the arm, for here, in contrast to the foot, the advantage of the lever system alters markedly with change in position. At full extension and greatest efficiency of the muscle, the lever system operates least advantageously; as the muscle shorten- and loses efficiency, the advantage of the lever system in creases. The fortunate consequence here is that the loss and gain tend to compensate each other so that from nearly full extension to a position at which the lower arm is at right angles to the upper, the lifting or pulling force obtained at the hand is nearly uniform. Beyond the point of right angles the mechanical advantage decreases and the lifting force falls off rapidly.

To give some figures for one subject: With the forearm at 49 deg to a line extended parallel with the upper arm, the pull of the muscle upon the tendon was 462 lb and the pull at the palm of the hand 44 lb. When the arm was flexed to an angle of 91 deg, the muscle had shortened 1 in.; its pull had fallen to 358 lb but the pull at the palm of the hand was 50 lb as compared to 46 at full extension. When finally the forearm was flexed 154 deg to a line extended parallel with the upper arm, the pull of the muscle was 244 lb and on the hand, only 18 lb. Fig. 5 gives the data from this experiment.

CONCLUSION

I present these values here only to illustrate general principles in the mechanics of two groups of muscles. It is a simple procedure to obtain similar values for any other muscles or groups of muscles; and I suggest no industrial or other application. Some applications are obvious and many even go beyond the factory and apply to the consumer use of a product requiring muscular effort in its operation.

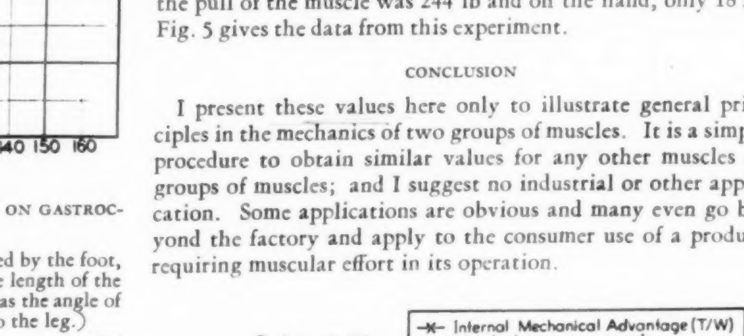

FIG. 5 DATA OBTAINED FROM MEASUREMENTS MADE ON BICEPS MUSCLE

(The pertinent feature here is the compensation of decreasing pull of the muscle by increasing advantage of the lever system on flexing the arm with the result of a nearly uniform force delivered at the hand from full to half flexion.)

ROUNDING EFFECT *in* CENTERLESS GRINDING

By ALBERT H. DALL

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DURING the last 25 years, the centerless method of grinding has developed into one of the most important production operations in industry. This development can be attributed to the many advantages which the centerless method affords. As is the case almost always in the development of new processes, the centerless method has not only replaced other methods in some instances but has greatly expanded the field of grinding.

ADVANTAGES OF CENTERLESS METHOD

The advantages of the centerless method which have led to the expansion of its use are as follows:

1 The centerless method affords a rigid work support. The work is supported rigidly directly opposite the grinding wheel.

2 The centerless method is adapted to continuous production with zero loading time on most parts.

3 The centerless method permits very accurate size control in production.

It is largely through the first advantage that the centerless grinder has expanded the field of grinding. Small fragile pieces can be ground at high production rates. Nonrigid materials such as cork can be ground. Such things as surgical sutures are regularly ground to size on the centerless grinder.

The centerless grinder produces "round" parts within very small tolerances. However, the process of rounding is entirely different from that of the center-type method. In the center-type method, the work is rotated on a fixed axis, and a surface of revolution is generated about this axis when the grinding wheel face penetrates the work boundary. In the centerless method, no fixed axis exists. The work is confined between three surfaces, i.e., regulating wheel, grinding wheel, and work blade. The grinding wheel is not truly a confining surface, except in a secondary sense, since it cuts away the workpiece wherever it contacts.

In Fig. 1 are shown the elements of the centerless grinder. The workpiece is supported by the blade and rotates with the grinding wheel and regulating wheel. The grinding wheel causes the work to rotate but the regulating wheel governs its speed of rotation. Since no perceptible slip occurs at the contact of the work and regulating wheel, the peripheral speed of the work is equal to the peripheral speed of the regulating wheel.

Fig. 1 shows the work center above the center line joining the wheel centers and also an angular-type blade. If the work center is placed on a line joining the centers of the wheels and a flat blade is used for support, it would seem that the piece would be ground to a constant diameter. Although this is true, it is unfortunate that many geometric shapes have constant diameter other than the circle. Further, it has been found in practice that more often than not, a three-sided figure, such as Fig. 2, is produced when the work is on center using a flat blade.

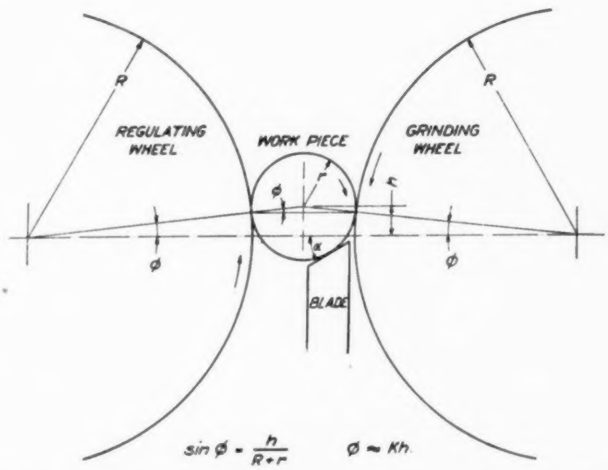


FIG. 1 THE GENERAL GEOMETRIC RELATIONS IN CENTERLESS GRINDING

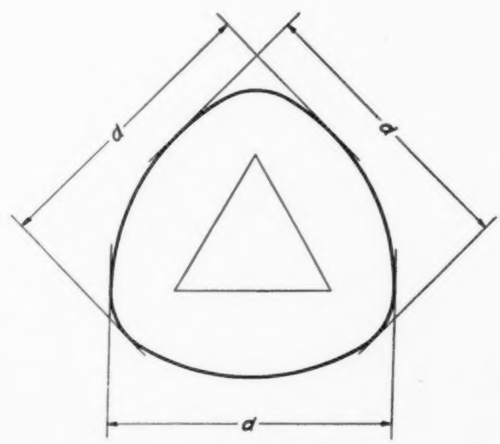


FIG. 2 THREE-LOBE CONSTANT-DIAMETER FIGURE

STUDY OF ACTION ON THREE-SIDED PIECE

Since the centerless method shows a tendency to produce three-sided figures, it would be significant, therefore, to investigate what happens when a three-sided constant-diameter piece is submitted to the centerless process.

Fig. 3 shows the results when a three-arc constant-diameter figure is presented to the centerless machine. In this graphical method the grinding-wheel surface is moved in at a constant rate for the first revolution of the workpiece. This rate is

Contributed by the Research Committee on Metal Cutting Data and Bibliography and presented at the Fall Meeting of the Cincinnati Section, Cincinnati, Ohio, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

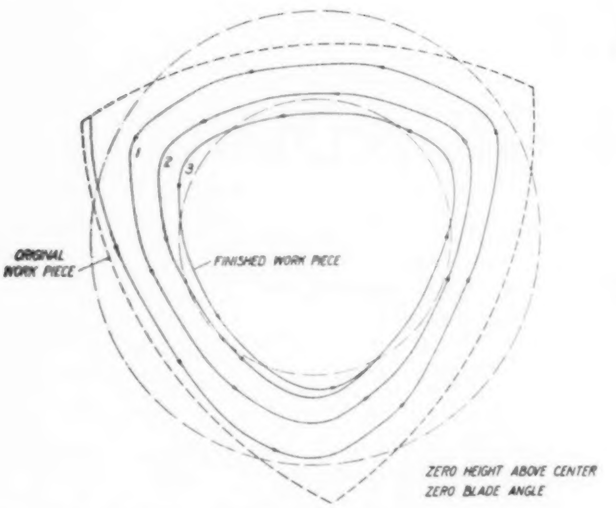


FIG. 3 ROUNDING EFFECT ON THREE-ARC CONSTANT-DIAMETER FIGURE WITH $\phi = 0$ AND $\alpha = 0$

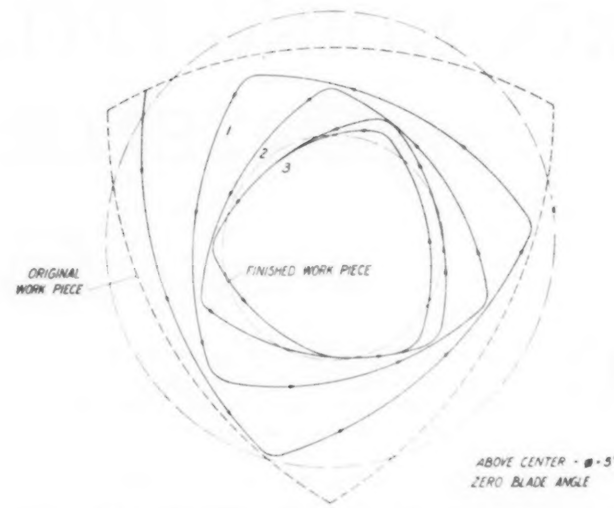


FIG. 5 ROUNDING EFFECT ON THREE-ARC CONSTANT-DIAMETER FIGURE WITH $\phi = 5$ DEG AND $\alpha = 0$

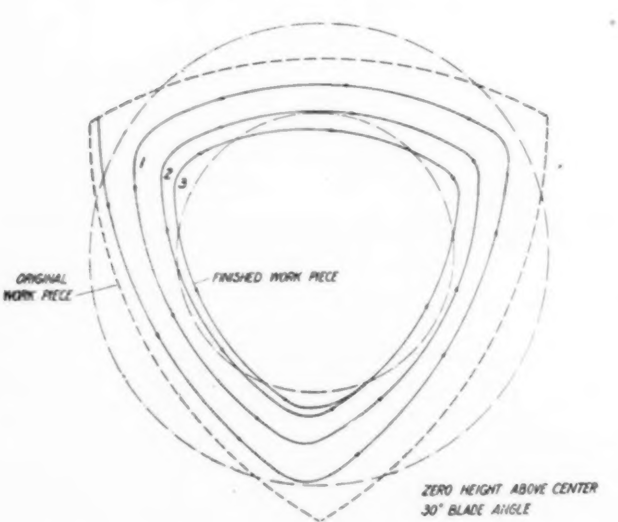


FIG. 4 ROUNDING EFFECT ON THREE-ARC CONSTANT-DIAMETER FIGURE WITH $\phi = 0$ AND $\alpha = 30$ DEG

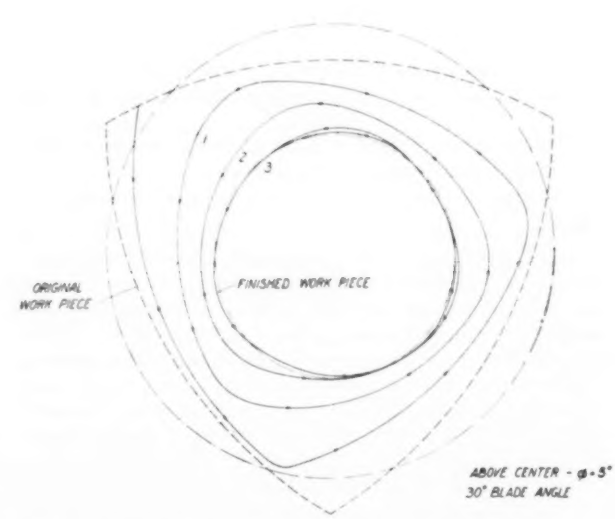


FIG. 6 ROUNDING EFFECT ON THREE-ARC CONSTANT-DIAMETER FIGURE WITH $\phi = 5$ DEG AND $\alpha = 30$ DEG

diminished for the second revolution and also for the third. The work is then rotated without further feed until the cut runs out. When the work is on center and supported by a flat blade, Fig. 3 indicates no perceptible improvement in roundness. Although the corners are blunted, the deviation from a circle has improved but slightly percentagewise.

Fig. 4 shows the same figure ground on center using a 30-deg angular blade. Again the improvement in roundness is negligible. In Fig. 5 the work is placed above center with a flat-top blade, and the results show a negligible improvement in rounding. It will be noted in this figure that the high points gradually swing clockwise. This will be called "phasing," and its cause can be associated with the fact that, when the work is above center, the contact on the grinding wheel is not diametrically opposite to the contact on the regulating wheel.

In Fig. 6 the work was placed above center using a 30-deg angular top blade. The improvement in roundness is marked.

It is therefore obvious that the geometric relations of the blade, regulating wheel, and grinding wheel have a profound effect on the rounding of the workpiece. It is also apparent in the centerless method that errors beget errors, and it is only by a process of diminishing errors that roundness is ever achieved.

MATHEMATICAL RELATIONS

The mathematical relations between the error produced by another error can be deduced. In Fig. 1 the notations of the angles are shown. Fig. 7 shows how the workpiece is displaced toward the grinding by an exaggerated positive error. The work is displaced a distance a in a direction normal to the regulating wheel. However, the work can move only in a line parallel to the blade. Thus the total movement of the work center, as shown in Fig. 8, is

$$\frac{a}{\cos(\alpha - \phi)} \qquad [1]$$

The projection of this distance on the normal to grinding wheel produces a penetration

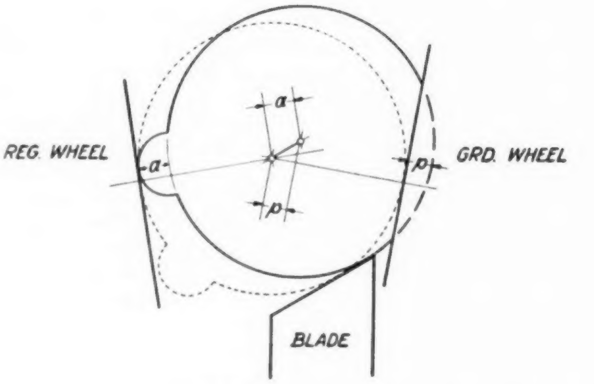


FIG. 7 PENETRATION AT GRINDING WHEEL CAUSED BY LARGE ERROR AT REGULATING WHEEL

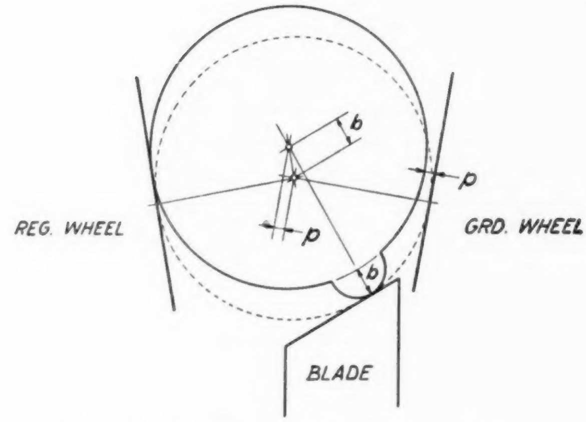
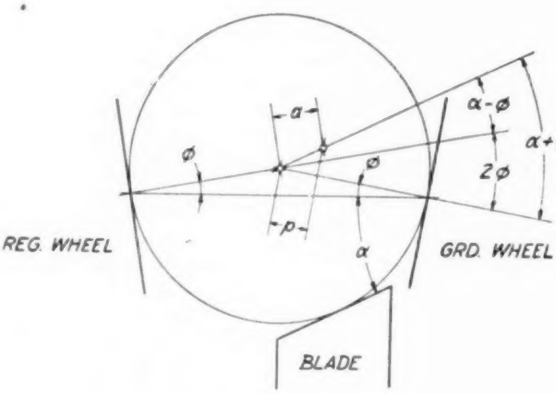
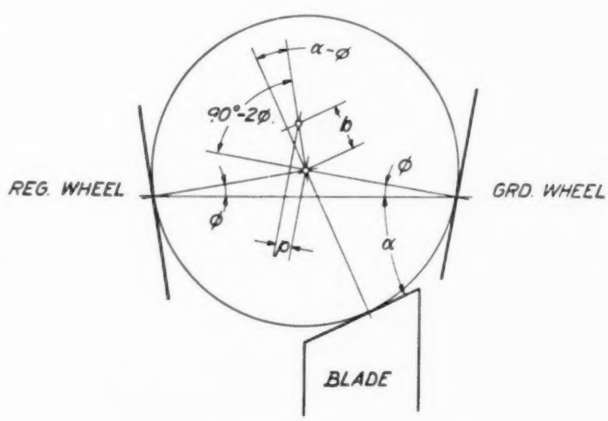


FIG. 9 PENETRATION CAUSED BY LARGE ERROR AT BLADE



$$p = -a\frac{\cos(\alpha+\phi)}{\cos(\alpha-\phi)}$$

FIG. 8 GEOMETRY OF CONDITION SHOWN IN FIG. 7



$$p = b\frac{\cos(90°-2\phi)}{\cos(\alpha-\phi)} = +b\frac{\sin 2\phi}{\cos(\alpha-\phi)}$$

FIG. 10 GEOMETRY OF CONDITION SHOWN IN FIG. 9

$$p = -a\frac{\cos(\alpha+\phi)}{\cos(\alpha-\phi)} \qquad [2]$$

A positive error will produce a negative error and vice versa.

This equation shows that the penetration will always be less than the error a if the angles ϕ and α are positive. The angle α is almost always positive in order to increase the component of force on the regulating wheel so that no slip takes place at this contact. When slip does take place, the work will spin with the grinding wheel.

In Fig. 9 is shown the effect of an exaggerated error when it contacts the blade. The work is displaced a distance b normal to the blade and the total movement is therefore

$$\frac{b}{\cos(\alpha-\phi)} \qquad [3]$$

The penetration p is again the projection of this movement on a line normal to the grinding wheel and is, as shown in Fig. 10,

$$p = b\frac{\cos(90-2\phi)}{\cos(\alpha-\phi)} = b\frac{\sin 2\phi}{\cos(\alpha-\phi)} \qquad [4]$$

This penetration has the same sign as the error. Thus a positive error will result from a positive error. The magnitude of the errors thus produced are small since ϕ is usually small. The effect of errors produced in this manner can be regarded as negligible.

Fig. 11 shows the per cent reduction in errors plotted versus height above center for various blade angles. The conditions of wheel sizes and work diameter are indicated in the figure. Taking a common condition of $^3/_8$ above center and 30-deg blade, it is seen that the correction is approximately 5 per cent. Each error that is reproduced is therefore 95 per cent of the error that produced it. A simple calculation shows that after 100 reproductions, the error would be only 0.6 per cent of the original error. Since the errors are reproduced in less than one half revolution of the work, it follows that 100 reproductions will take place in less than 50 revolutions of the work.

When the work is above center, Figs. 5 and 6 show that the errors are phased, which means that the reproduced errors do not occur 180 deg from the original errors but occur approximately $(180 - 2\phi)$ from the original errors.

Fig. 12 shows the per cent reduction of errors plotted versus blade angle for the various heights above center.

The question may arise, why not place the work high above center and use a high-angle blade at all times? If light cuts are taken with a sharp wheel, these extreme conditions can sometimes be used. Under ordinary production conditions, however, the forces increase as the wheel becomes dull. The high angle on the blade forms a wedge with the regulating wheel which may cause the work to jump upward. The work may jump so violently as to leave the machine.

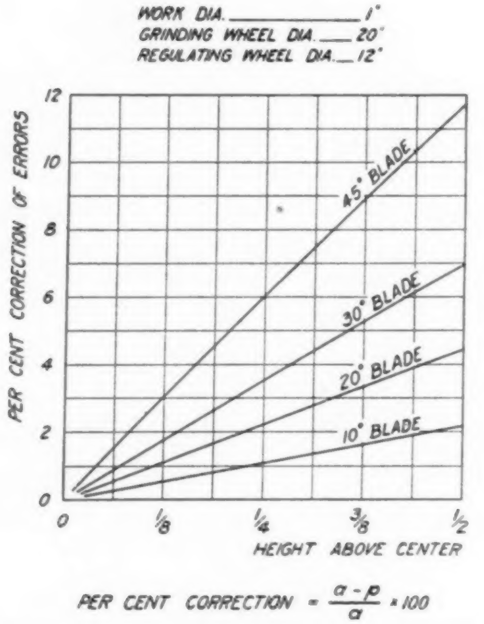


FIG. 11 CHART SHOWING PER CENT CORRECTION OF ERRORS VERSUS HEIGHT ABOVE CENTER FOR VARIOUS BLADE ANGLES

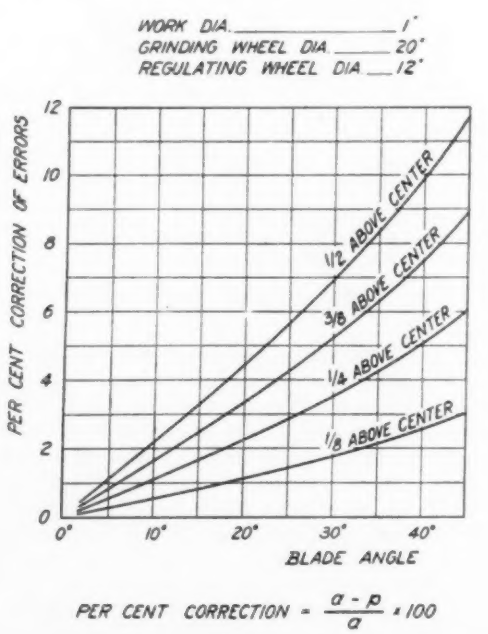


FIG. 12 CHART SHOWING PER CENT CORRECTION OF ERRORS VERSUS BLADE ANGLE FOR VARIOUS HEIGHTS ABOVE CENTER

ADDITIONAL ROUNDING FACTORS

There are other factors which contribute to rounding. These factors are as follows:

1 Center shift.
2 Wheel interference.
3 Elasticity of the wheels.

These factors do not submit to mathematical analyses because their effect varies greatly with the magnitude and character of errors.

Of the three factors, the most important is that of center shift. For instance, if a piece has a negative error on one side, a positive error will be created almost diametrically opposite. The positive error will again create a negative error in the same quadrant as the original negative error. Thus the original negative error tends to spread on one side of the piece while the positive errors will spread on the other side. This will cause a shift in center of the workpiece away from the original negative error. The phase shift is important in this case in order to get a spreading of the error. As the errors move around the piece, the geometric correction causes the errors to diminish. Thus the errors at right angles to the radial line will be much diminished.

Wheel interference is effective only in diminishing the errors when the errors are large. A large, sharp, negative error will produce a blunted positive error because of the large radius of curvature of the regulating wheel. Sharp errors will also be blunted at the grinding wheel because of its large radius of curvature.

The elasticity of the wheel surfaces will also cause a decrease of magnitude in the reproduced errors because of increases in normal pressure against these wheels. When the stock removal is large at the instant of generation of large negative errors at the grinding wheel, the forces on the wheels increase for an instant, which results in wheel deformation and a consequent decrease in the errors so produced.

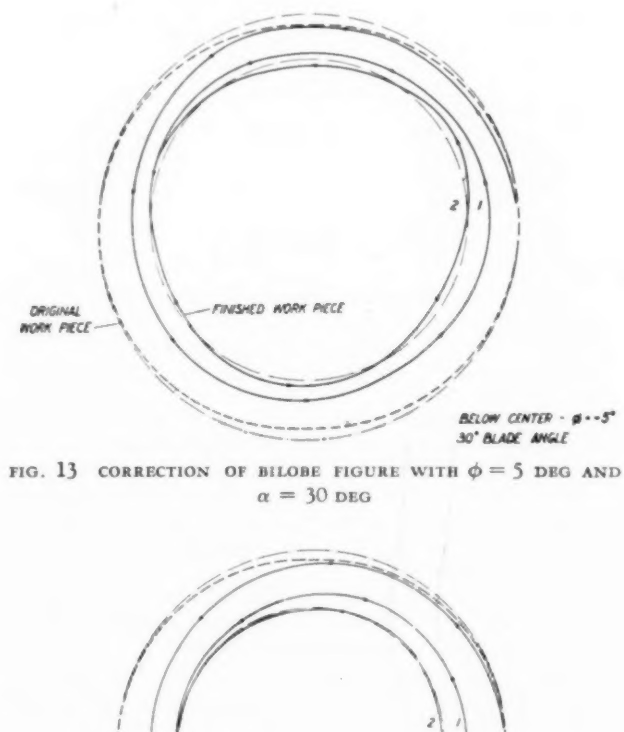


FIG. 13 CORRECTION OF BILOBE FIGURE WITH $\phi = 5$ DEG AND $\alpha = 30$ DEG

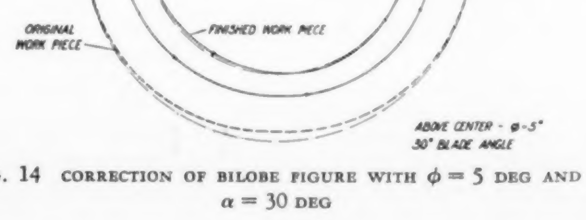


FIG. 14 CORRECTION OF BILOBE FIGURE WITH $\phi = 5$ DEG AND $\alpha = 30$ DEG

When the errors are small and well distributed, none of the last three factors is important.

PROBLEMS IN ROUNDING

Figs. 13 and 14 illustrate two extremes of geometric conditions and their effect on the rounding of a bilobed piece. In Fig. 13 the work is above center ($\phi = 5$ deg), and a 30-deg blade is used. The rounding is accomplished very quickly. Close inspection shows that the workpiece changes from a two-lobe to three-lobe figure. In Fig. 6 it is seen that a three-lobe piece will gradually change to a circle under the conditions obtaining in Fig. 13.

In Fig. 14 the work was placed below center $\phi = 5$ deg with a flat-top blade. Here the two-lobe figure degenerates into a rather sharp three-lobe figure. From Fig. 3 it is seen that this three-lobe figure will not improve even when the work is on center using a flat-top blade.

Other problems in rounding are often encountered in centerless grinding. One of these problems is that of so-called "chatter." The fundamentals of rounding are not usually involved, except in a secondary sense. As has been pointed out previously, the forces acting on the blade increase as the blade angle increases. Further, these forces acting on the high-angle blade will have an increasing horizontal component due to the angle itself. Blade deflection and consequent vibration, therefore, occur with greater ease. As the height above center increases, the work is not as firmly confined as when it is nearer to center. This may cause a jumping of the workpiece and a consequent variation in forces necessary for the beginning of a vibration.

The natural frequency of one of the structural members which support the regulating wheel, grinding wheel, and blade is usually the frequency at which chatter occurs. Once a series of flats are ground into the work at a spacing corresponding to the frequency of one of these members, the vibration has a tendency to produce resonance, because flats so produced will produce other flats until the whole periphery is covered.

Structural rigidity with correspondingly high natural frequency prevents such self-induced vibrations, because the arc of contact of the wheels will cover more than one flat. When this condition is obtained, the vibration is damped.

CONCLUSION

The factors involved in the rounding effect of centerless grinding provide a wide latitude for adjustment for almost any condition encountered in practice.

A knowledge of the criteria for rounding is a requisite for the intelligent adjustment of these conditions. However, other conditions of the setup than blade angle and height above center must be taken into consideration for precision grinding. These conditions are as follows:

1 On through-feed grinding, the guides for the pieces entering and leaving the wheels must be properly adjusted for both position and parallelism.

2 On long pieces, the portion extending from the wheels should be prevented from whipping by using proper fixtures.

3 In through-feed grinding, the tilted regulating wheel must be trued so that it contacts the work throughout its length.

Faults in the three conditions sometimes cause marks in the workpiece which are often erroneously attributed to the geometric setup.

The centerless-grinding method is capable of producing round parts well within the limits of parts produced by the center-type method. Parts have been ground in production to within less than 0.000025 in. for roundness. Although the center-type method should produce perfectly round pieces theoretically, there are many factors such as imperfect centers, work elasticity, work driving method, etc., which sometimes cause out-of-roundness far exceeding the figure just quoted.

ACKNOWLEDGMENTS

The author wishes to express his appreciation to Mr. Hans Ernst and Mr. Walter Schroeder for their help in the preparation of this paper.

World's Largest Airport

WORK is now progressing on the second stage of Idlewild Airport at Jamaica Bay, an airfield which will make New York City the world's foremost airport as well as seaport. Started in 1942, stage construction calls for completion in the fall of 1950.

An article, "Idlewild–Airport of the Future," in *Excavating Engineer*, February, 1946, reveals some of the facts and figures about the building of this gigantic airfield.

The site of the air terminal was developed by utilizing 60,000,000 cu yd of sand fill, dredged from Jamaica Bay to lift the area seven feet above mean high tide and to solidify approximately 4853 acres of meadow and marshlands previously cleared of 1000-odd homes, cottages, fishing shacks, abandoned hotels, and boatyards.

By spring of 1949 it is expected that six runways will be in operation, the taxiway system completed, permanent administration building in use, with suitable approach roads, and parking facilities. After the final stage, the airport will include 12 longitudinal runways, over 40 hangers, a 12,000-ft serpentine loading platform, 20 miles of highways, and parking space for 30,000 motor vehicles.

The planned $16^1/_2$ total miles of tangential runways are 12 in. thick and 200 ft wide, with 50-ft shoulders sloping to a complete drainage system. Like taxiways and apron, they are designed to carry the 75,000-lb wheel loads of cargo-filled 300,000-lb planes.

Some runways will be capable of extension in length should increased plane size so require. The three completed runways constructed in the first stage are 10,000 ft, 8200 ft, and 7600 ft, respectively. Runways to be completed in other stages of construction include one 11,200-ft, one 6800-ft, and seven slightly more than a mile in length.

Paralleling runways are built at least a mile apart so that planes can maintain schedules whether landing by contact or by instrument, and regardless of traffic, wind, fog, hail, snow, or zero ceilings.

Three planes can take off and three can land simultaneously and safely on six runways. Further development of instrumentation and use of radar are expected to make possible take-offs and landings at 60-second intervals on opposite runways, permitting operations on the order of 240 to 360 plane movements hourly, or four to six each minute.

It is expected when completed, that a permanent air terminal staff of 40,000 will handle daily passenger traffic estimated at 30,000 persons and daily cargo movements calculated at 20,000 lb of mail, and 100,000 lb of merchandise.

Idlewild, the world's greatest airport, will definitely place New York in the center of the world's air map. This pioneering international air terminal is dedicated to the purpose of meeting and serving new concepts of transportation, time, and geography.

The TER MEER *Continuous* CENTRIFUGAL

By H. F. IRVING

PROCESS ENGINEER, BAKER PERKINS, INC., SAGINAW, MICH. MEMBER A.S.M.E.

CENTRIFUGALS or centrifuges are designed to separate a mixture of two or three materials into its components by the use of centrifugal force. In some cases it may be the separation of two liquids having different specific gravities, as in the case of the cream separator; in others, the separation of oil, water, and a solid sludge, as in clarifying lubricating oil from machines. In still others the separation is accomplished by using centrifugal force to accelerate filtration.

The ter Meer continuous centrifugal is designed to accomplish the last-named type of separation and, owing to its construction, finds its application in the separation of relatively coarse free-draining solids from liquids. By coarse solids is meant a material having not more than 10 to 20 per cent of its particles finer than 100 mesh.

DETAILS OF TER MEER CENTRIFUGAL

Referring to the cross section of the machine shown in Fig. 1, the centrifugal consists of an overhung, horizontal, perforate drum (1) mounted on the end of a shaft (2) which is in turn mounted rigidly in two bearings (3). Inside the drum is a screen (4) having fine slots parallel to the axis of rotation. The outer end of the drum is open. At the back end of the shaft is the drive pulley and between the bearings, part of the shaft is enlarged to form a cylinder or servomotor (5). The part of this main shaft (2) from the cylinder to the drum is hollow to accommodate the pusher shaft (6) which at one end is connected to the piston of the servomotor and at the other to the pusher (7). The pusher is a circular plate which fits closely inside the screen at the back of the basket or drums. Collector rings (8) are fitted to the main shaft on each side of the servomotor with suitable ports for admitting and exhausting oil from either side of the piston. The piston is keyed to the cylinder and pusher shaft, and the pusher shaft to the pusher so that all these parts rotate with the drum. As they rotate, oil is admitted first to one side of the piston and then to the other so that the pusher moves back and forth in the direction of the axis of rotation. An oil reservoir, pump and valves are provided to actuate the servomotor.

On the front side of the pusher is mounted a ring of lugs which support a funnel (9) and leveling ring (10). The funnel is placed with the large end next to the pusher, and the small end extends through the front part of the dry housing (13). Around the drum is placed a liquor housing (11) to collect the liquor thrown out of the holes in the drum wall. Leakage from the housing is prevented by labyrinth seals (12), at the front of the drum and at the main shaft. A liquor drain is provided and also a vent to prevent any build-up of air pressure in the housing which might cause the seals to leak. The dry housing (13) is provided at the front of the machine to catch the solids pushed off the front of the basket and direct them down through the discharge opening (14).

Contributed by the Process Industries Division and presented at the Annual Meeting, New York, N. Y., Nov. 26–29, 1945, of The American Society of Mechanical Engineers.

Fig. 2 shows a completely assembled machine with the feed pipe, solids and liquor discharges, hydraulic pump, pump motor, and hydraulic controls clearly visible.

In Fig. 3 the dry housing, upper half of the liquor housing, and upper half of the servomotor housing have been removed to show the assembly.

Fig. 4 is a view from in front of the machine with the dry housing removed to show the screen, funnel, and leveling ring. The screen in this particular machine was a Wedgewire and two segments have been removed and placed in front of it.

OPERATING SEQUENCE

In operation, with the drum rotating at the desired speed and the pusher moving back and forth, slurry is introduced in the small end of the funnel. As it passes down the inside of the funnel, it is spread out and accelerated to nearly the full basket speed. At the large end of the funnel it is thrown out through the spaces between the funnel support lugs onto the screen between the pusher and the leveling ring. Immediately, the liquor is thrown out through the slots in the screen and a cake of the solid material starts to build up. As the cake builds up, it is pushed forward by the pusher on the forward stroke, and on the back stroke the excess is raked off the top by the leveling ring into the space left by the pusher. As the cake is pushed along the drum more liquor is drained off, and it may be washed by a spray of liquid just in front of the leveling ring, if desired. It then continues to drain until it reaches the end of the drum where it is thrown off into the dry housing.

The advantages of the machine are fairly obvious: (1) The only power required is that to overcome the friction and windage of the machine, to push the cake, and to accelerate the slurry. (2) Being continuous, there is no lost time and the tonnage output is large for the size of the machine. (3) Being simple and continuous, the maintenance and operating costs are low. (4) It is completely enclosed so that toxic or obnoxious materials can be safely handled. (5) Crystal breakage is very low. (6) By placing a baffle in the liquor housing the mother and wash liquors can be readily separated.

The machine also has certain limitations, as follows: (1) It is limited to materials which can be retained satisfactorily on a slot-type screen having openings of about 0.010 in. or larger, since the cake cannot be pushed across any other type, and so far screens with finer slots are not available. (2) Only fairly fast-draining materials can be handled as it is impractical to use a retention time of more than about 3 min, and very slow-draining materials have a tendency for the slurry to wash out the front of the basket into the dry housing.

CONSIDERATIONS OF DESIGN AND OPERATION

In the design of this machine the drum is subjected to the same stress as a batch centrifugal plus the axial load of the pusher so that the drum and particularly the drum hub (or end plate) must be strong enough to stand the combined load. Also the normal stresses in the material must be kept low to allow a

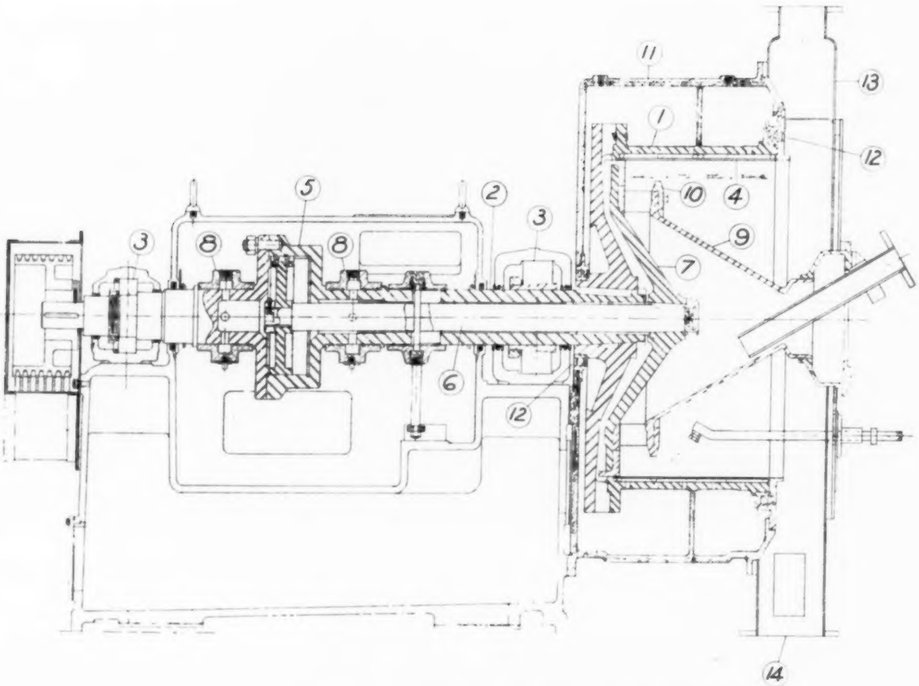


FIG. 1 CROSS SECTION THROUGH TER MEER CENTRIFUGAL

generous margin of safety for out-of-balance loads which in a rigidly mounted basket may be very high.

It is evident that the cake thickness, density, and length, drum speed, and pusher load are all related, that is, there must be some relation between the cake thickness and length. Also the pusher load required to move the cake must be equal to the pressure of the cake against the screen times the coefficient of friction, and this pressure of the cake against the screen is equal to the mass of the cake times the centrifugal force employed.

An analysis of the relation between cake thickness and length shows that for any given material there is a maximum ratio of length to thickness which cannot be exceeded if the cake is to push smoothly and maintain a perfectly uniform thickness throughout its length. This ratio varies from about 4 to 10, depending on the material, but for most materials it is about 6. For a given length basket then, any cake thickness greater than the minimum may be employed, but an attempt to use one thinner than this will result in the cake's compressing until it reaches this thickness. In the process of compressing it is apt to become uneven and out of balance. It is interesting to note that this maximum ratio of cake length to thickness is independent of the centrifugal force employed since the compressive strength of the cake and frictional resistance are both direct functions of the centrifugal force.

As stated, any cake thickness greater than the minimum will push satisfactorily, but as the thickness is increased the pusher load increases. Since the pusher load is the product of the mass of the cake, the centrifugal force, and the coefficient of friction, and since the pusher load must be held to a reasonable value, the thicker the cake, the lower the centrifugal force which may be employed. In general the liquor content of the discharged salt drops more rapidly with an increase in centrifugal force than it does with a comparable increase in retention time, so that the centrifugal force employed should be as high as possible and therefore the cake thickness should be only slightly greater than the minimum required. If, however, output is more important than low liquor content, the centrifugal force can be reduced and the cake thickness increased.

The function of the funnel is to distribute and accelerate the slurry passing onto the screen. The angle of the funnel is usually 30 deg from the axis which gives satisfactory acceleration without salting out on the funnel. The point of discharge from the funnel onto the basket must be far enough from the pusher so that the cake will build up to the leveling ring before it starts to push off. This is particularly important where the desired cake thickness is considerably greater than the minimum necessary to push off, because if it is deposited too close to the pusher it will push off as soon as the minimum thickness required to push off is reached. Under this condition, the desired retention time will not be obtained, the cake may not be uniform, and out-of-balance stresses and vibration will be set up.

The length of the pusher stroke is usually about $^1/_{10}$ the length of the basket, the maximum being slightly greater than this with adjustable stops so that it can be reduced as much as desired. The oil to the servomotor is furnished by a positive-displacement Vickers pump so that unless oil is bled off between the pump and servomotor, the frequency of the push is determined by the length of the stroke, size of piston, and volume of oil pumped. In a particular machine a decrease in the length of stroke results in a corresponding increase in the frequency.

The range of frequencies is from about 10 strokes per min in the 48-in-diam-drum machine to 60 or 70 strokes in the 12-in. laboratory model. In the design of the hydraulic system, the length of the cake to be pushed, its thickness, density, coefficient of friction, and minimum retention time must be established. Then the pusher load can be calculated and also the volume of cake pushed per minute. Then a diameter of servomotor can be selected which will give the desired push without using too high an oil pressure. By keeping the oil pressure to 350 psi, or lower, close-fitting bronze collector rings will oper-

ate satisfactorily without the use of packings. Knowing the cake thickness and volume of salt to be pushed off per minute, and assuming the maximum effective stroke (that is, that part of the stroke when the entire cake moves) to be 75 per cent of the total, the frequency for a given stroke can be determined. Next, from the diameter of the servomotor, frequency and length of stroke, the volume of oil required is computed and, allowing 20 per cent for leakage, the pump capacity is established.

The oil is directed to and from the servomotor by a four-way hydraulically operated valve controlled by a four-way pilot valve which is operated by adjustable stops connected to the pusher shaft. A relief valve is supplied at the pump discharge to relieve oil back to the reservoir in case the pusher stalls. Also a flow control is installed so that a portion of the oil from the pump can be bled back to the reservoir in case it is desired to reduce the pusher frequency.

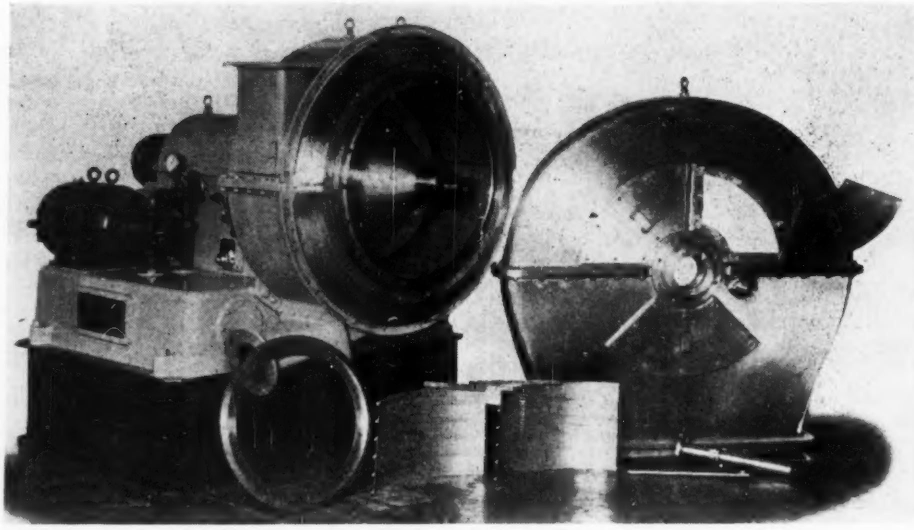


FIG. 4 FRONT VIEW OF MACHINE SHOWING DRY HOUSING REMOVED TO SHOW SCREEN, FUNNEL, AND LEVELING RING

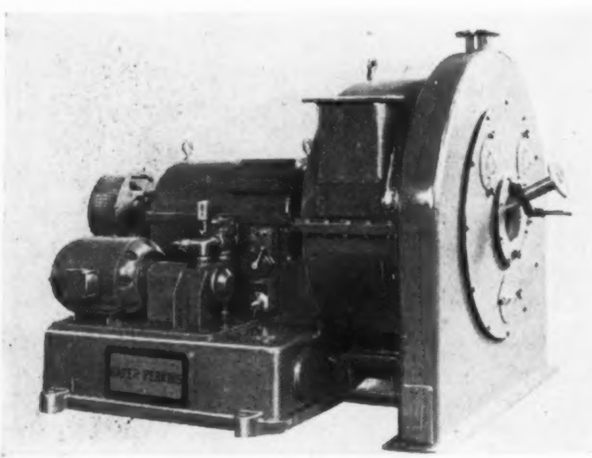


FIG. 2 ASSEMBLED CENTRIFUGAL

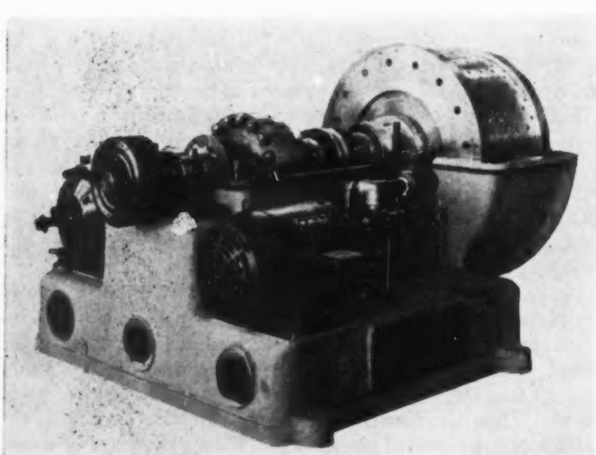


FIG. 3 DRY HOUSING, UPPER HALF OF LIQUID HOUSING, AND UPPER HALF OF SERVOMOTOR HOUSING

TYPES OF THE SLOTTED SCREENS USED

As stated before, it has been found impossible satisfactorily to push a cake over anything but a slot-type screen with a smooth surface. Three types are in current use. The first is a "slotted-plate" type in which a thin plate has fine parallel slots milled in it. The second is the "Wedgewire" screen in which wedge-shaped wires are laid side by side and looped around a rod at intervals of $2^3/_4$ in. Where the wire crosses itself at the top of the loop, it is squeezed together in a press until the thickness at that point is just enough greater than that of the wire to give the desired width of slot. A third type is called the "Wedgslot" screen and is composed of fine bars or wires having a modified T-section and placed side by side, with the webs held so as to maintain the desired width of slot. In none of these types, however, are uniform slots less than about 0.010 in. available, nor bar widths less than about 0.080 in.

The ter Meer centrifugal can be operated satisfactorily at almost any capacity from 0 to maximum since the effective stroke can be anything from 0 to 75 or 80 per cent of the actual. The maximum capacity varies considerably depending on the material handled and what the limiting factor is. In one case it may be the moisture content of the discharged salt, in another the degree of wash obtained, and in a third the output may be limited by the drainage area of the screen. In the case of one free-draining salt an S-48" ter Meer had a capacity of 110 tons per day with a moisture content of 3.5 per cent in the discharged salt while, with a moisture content of 5.5 per cent, the capacity could be increased to 300 tons per day. In a case where the limiting factor was the degree of wash obtained, an S-30" ter Meer was limited to an output of $1^1/_4$ tons per hr, whereas, the same machine on ammonium sulphate has an output of from 4 to 6 tons per hr. On a fibrous material recently tested in the laboratory, a capacity of about $^1/_2$ ton per hr was predicted for the same-size machine.

(*Continued on page 343*)

Measurement and Appraisal of ORDNANCE ARSENAL PERFORMANCE

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During the recent war the Ordnance Department made substantial improvement in the operation of its installations by the use of the most up-to-date methods of management. Its efforts were prompted by the desire to operate on an efficient and economical basis and were stimulated by the critical shortage of manpower. It was realized early in the war that the most critical and precious element in the production program was a man-hour of labor, and every effort was made through various programs of improvement to bring about economical use of manpower. However, the continuing scrutiny of methods of work, procedures, organizational arrangements, and other elements involved in the operation of installations was not enough.

It soon became apparent that there should be established some means of appraising the performance of an installation on individual activities and groups of activities, and providing month-to-month comparisons. Such information would serve as an indication of progress and furnish the basis for executive action.

The first efforts of the Ordnance Department and the Army as a whole in this direction consisted of the establishment of broad categories of activities, reports of manpower utilized in those activities, and work-load data for each. Invariably, such categories were so broad, and required the use of such broad units of measure, that the resulting information was not indicative of the effectiveness of manpower utilization.

These early plans made it apparent that if an adequate method of appraising performance were to be developed, installation activities would have to be considered in terms of their component operations and in terms of more representative units of work.

This paper presents the method developed by the Ordnance Department for the measurement and appraisal of performance of its arsenals.

FUNCTIONS OF THE ARSENALS

The arsenals of the Ordnance Department have as their assigned mission the design, development, and production of ordnance materiel. It is their responsibility to keep manufacturing techniques at the highest level of development as is possible, with the aim of passing them on to private enterprise when, as in time of war, the latter picks up the production load. The arsenals are the laboratories and experimental shops for ordnance materiel and are generally engaged in short-order production, in limited production for the development of production techniques in commercial plants, or in development and research, which is both technical and manufacturing in nature.

The Ordnance Department has under its jurisdiction eight manufacturing arsenals, seven of which are located on the eastern seaboard. The combined facilities of these installations contain 20,000,000 ft of building space.

The personnel strength for this group of installations reached 86,000 shortly after Pearl Harbor, when the pressure for production was greatest, and was gradually reduced to a level of about 55,000 as private enterprise picked up the continually increasing production load.

Each arsenal has its special manufacturing assignment for a given group of items or components, and the type of production at any one is not comparable with that of the others. For example, Springfield Armory is assigned the development and establishment of production techniques for certain small-arms weapons, particularly the M1 rifle; Picatinny Arsenal is fundamentally an experimental and development installation for powder, as well as a producer of special-purpose ammunition; Rock Island Arsenal is set up primarily on a job-shop basis, and is responsible for widely diversified types of materiel, from the manufacture of small-arms weapons and recoil mechanisms for all sizes of guns to the remanufacture of medium tanks; Frankford Arsenal specializes in fire-control instruments, small arms, and artillery ammunition; and Watertown and Watervliet Arsenals have as their major assignments gun carriages and gun tubes, respectively.

DEVELOPMENT OF MEASURES OF PERFORMANCE

The differences in arsenal missions prevented direct comparison among arsenals of practically all manufacturing operations.

Within each arsenal the wide range of end products, including spare parts, the complexity of operations, and the use of arsenal facilities for partial manufacture of end items made it impracticable to appraise performance of the arsenal as a whole through the use of such units of work as "guns," "rifles," "recoil mechanisms," etc. Under such conditions, adequate measures of performance could be developed only on the basis of functions or operations, such as milling, boring, storing, paying, etc., regardless of the end product. On this basis, a careful analysis was made of all activities in order to develop a list of functions and operations which would cover the work of all arsenals, regardless of mission.

These functions and operations were clearly defined to fix the items of work included in each, and to assure common understanding (see Fig. 1). These descriptions provide the basis for making correct labor charges. Each of these functions, as defined, was then carefully examined from the measurement standpoint. The selection of functions and operations for measure-

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ment and the determination of units of measure for each were governed by the following considerations:

1 The work involved must be of sufficient importance technically to make measurement desirable.

2 Measurement must be worth while from the standpoint of number of people engaged in the work.

3 The operation must be stable, i.e., one which is not likely to be discontinued in the immediate future.

4 The work involved must not be so complex and varying in nature as to make measurement impractical.

5 For the measurable functions, the unit or units of measure should be representative of the effort required.

In determining measures of performance, the Ordnance Department was concerned with the effectiveness of groups of people rather than with the efficiency of individual employees in a group.

ACTIVITY: TRANSPORTATION

OPERATION: Commercial Traffic

Definition: Administering the transportation function; securing reservations and issuing transportation requests and meal tickets; maintaining records of incoming and outgoing freight, status of demurrage, and storage in transit privileges; furnishing a daily list of inbound and outbound cars and intra-arsenal movements; insuring conformance with carriers freight classification, rules, regulations, and tariffs prescribed by the I.C.C., Army Regulations, and other authorities; arranging with carriers for truck transportation; preparing bills of lading on outbound shipments and accomplishing them on inbound shipments; controlling and recording Government bills of lading; obtaining routings and ODT releases; diverting and reconsigning cars when authorized; ordering cars stopped in transit pending instructions for disposition; certifying demurrage bills and other miscellaneous transportation charges; furnishing routings and information to carriers for shipments; furnishing wire notices of shipments to consignees, if required; arranging with carriers to provide an adequate supply of empty cars to make shipments on schedule; tracing and expediting shipments.

WORK UNIT: Bill of Lading.

Work Unit Definition: Each bill of lading or dray ticket received and issued.

FIG. 1 SAMPLE OPERATION DEFINED

While, theoretically, anything can be measured if broken down fine enough, measurement was not applied where the results obtainable would not justify the effort to obtain them. Examples of kinds of work which were not considered practical of measurement are those under the general category of "Engineering," such as engineering "Laboratory," "Materiel Engineering," "Plant Engineering," etc.

Where it was found necessary to designate more than one unit of work as the measure of performance for a given function, owing to its complexity, production records were examined to determine if the proportion of the various units remained the same from month to month. If such were found to be the case, a single unit was selected as representative of the work done. If, however, the proportion of the various units was not reasonably constant, as is usually the case, the function was either split up into two or more operations, each with its single unit of measure, or multiple units of measure were established. Where multiple units were used, it was necessary to accumulate the quantities of each unit processed each month, in order that these values could be multiplied by their respective man-hour standards, to determine total standard man-hours for the function. Once standards were established, it was not necessary to keep records of actual hours expended on the processing of each type of unit.

The functions covering all arsenal activities and data with respect to their measurement are presented in Table 1.

The elements of work involved in many of the nonmanufacturing functions listed were neither highly repetitive nor standardized in method, which made precise measurement impracticable. While these conditions do not permit highly accurate measurement, the units of measurement established for these activities make possible a reasonably satisfactory appraisal of the performance. More precise methods of measure-

TABLE 1 LIST OF ARSENAL ACTIVITIES AND MEASUREMENT DATA

Function	Work unit
Administration—Arsenal:	
Administrative	Arsenal man-hour
Communication	Not measured
Janitorial	Thousand sq ft
Management	Not measured
Medical service	Not measured
Printing and reproduction	Not measured
Procurement	Document
Other administrative	Not measured
Engineering:	
Laboratory	Not measured
Materiel engineering	Not measured
Plant engineering	Not measured
Repairs and maintenance	Not measured
Fiscal and Finance:	
Cost accounting	Order
Finance	Multiple
Fiscal	Multiple
Inspection:	
Acceptance testing	Unit of prod.
Administrative	Inspection man-hour
Gage inspection and control	Not measured
Maintenance:	
Office appliance maint.	Appliance repair
Vehicle maintenance	Multiple
Manufacturing:	
Administrative	Mfg man-hour
Production planning, scheduling, and control	Expenditure orders, job orders, and addenda
Production	Multiple
Motor Pool:	
Admin. and maint.	Vehicle
Vehicle operation	Mile
Personnel—Civilian:	
Civilian pay roll	Civilian man-hour
Pers. administration	Civilian man-hour
Other personnel	Not measured
Property:	
Major rewarehousing	Not measured
Property disposal:	
Administrative	Line item
Salvage	Multiple
Receiving, storing, issuing, and shipping	Ton
Stock records	Property voucher processed
Repairs and Utilities:	
Admin. and property	Repair and utilities man-hour
Grounds, pavements, and railroads	Multiple
Repairing	Square foot
Utilities services	Plant by type
Other	Not measured
Safety and Security:	
Admin. and intelligence	Not measured
Fire prev. and protection	Not measured
Interior guard	Not measured
Plant safety	Not measured
Transportation:	
Commercial traffic	Bill of lading
Rail operation	Car spotted

PERFORMANCE RECORD

Installation: Frankford Arsenal — Division: Small Arms Ammunition — Shop: SU — Period: June 1945 — Coverage: 88 %

NOTE: Instructions on reverse side of sheet

	Activity or Operation (a)	Work Unit (b)	Standard Man-Hours per Work Unit (c)	Quantity Processed (d)	Man-Hours Standard (e)	Man-Hours Actual (f)	Percent Effectiveness This Period (g)	Percent Effectiveness Last Period (h)
DIRECT LABOR (Measured)	P.D.: 113	per M						
	.30 Carbine Case Prime	M	.4528	641.9	291	574		
	Total:-Prime Section				291	574	51	70
	.30 Carbine Ctg. Load	"	.4389	610.4	268	298	90	85
	.45 Tracer, T30 " "	"	.4362	272.9	119	227	53	-
	M7 Aux. Gren. " "	"	1.1280	1534.4	1,731	1,593	109	100
	Total:-Load Section				2,118	2,118	100	106
	.30 Carbine Pack in Chests	"	.4007	601.6	241	222	108	78
	.45 Ball " " "	"	.5077	713.2	364	336	108	96
	M7 Aux. Gren. " "M1917	"	1.6673	1151.2	1,919	)		
	" " " " " Ctns.	"	1.2350	869.5	1,074	)		
	" " " " "M9 Box	"	2.1142	450.0	951	)		
	" " " " " Ctns.	"	1.6667	496.5	828	6,073	79	65
					5,377	6,631	81	68
	1. TOTAL DIRECT LABOR (Measured)				7,786	9,323	83	80
DIRECT LABOR (Not Measured)	.45 Ctg. Ball Water proof					158		
	.45 Tracer, T30 Packed					515		
	.30 & .45 Stencil Test, etc.					192		
	.45 Tracer, T30 Point Identify					111		
	M7 Aux. Gren. Clean					467		
	Special Project					50		
	Experimental					108		
	2. TOTAL DIRECT LABOR (Not Measured)					1,601		
3. TOTAL ACTUAL DIRECT LABOR						10,924		
4. TOTAL INDIRECT LABOR		Standard Ratio		17.5%	1,915	2,369	81	86
5. TOTAL ACTUAL DIRECT AND INDIRECT LABOR						13,293		
6. SUPERVISORY AND ADMINISTRATIVE		Standard Ratio		3.2%	425	382	111	138
7. SHOP EFFECTIVENESS					10,126	12,074	84	82

INSTRUCTIONS

COLUMN (a) – Brief title of activity operation or group of operations on an item or class of item.

COLUMN (b) – For each entry in Column (a) show work unit. This may be expressed in terms of "piece", 1,000 rds., tons, etc.

COLUMN (c) – Standard man-hours corresponding to each work unit as recorded in Column (b).

COLUMN (d) – Quantity of work units completed during reporting period.

COLUMN (e) – For each entry in Column (a) compute standard man-hours by multiplying standard man-hours per work unit by number of work units produced *(Cols (c) x Cols (d))*.

COLUMN (f) – Man-hours expended for each entry in Column (a).

COLUMN (g) AND (h) – See explanation of effectiveness in lines 1 through 7

LINE 1
The percent effectiveness of direct labor is obtained by dividing the total standard direct labor hours in line 1, Cols e (1e) by total actual direct labor hours (1f) and multiplying by 100. Record this figure to the nearest whole number in (1g). The effectiveness of direct labor for individual items and operations need not be determined.

LINE 2
Determine **"TOTAL DIRECT LABOR** *(Not Measured)*" (2f) by adding the actual direct labor man-hours for each item and/or operation not measured. Corresponding quantities processed may be recorded for future use, where desirable.

LINE 3
Obtain **"TOTAL ACTUAL DIRECT LABOR"** (3f) by adding the total actual direct labor *(measured)* and the total actual direct labor *(not measured)*, *i.e.*, (1f) plus (2f).

LINE 4
Record the standard ratio of indirect labor to direct labor in (4d). This ratio is the standard number of indirect labor hours required for every hundred actual direct labor hours. Apply this ratio to the total actual direct labor (3f) to obtain standard man-hours for indirect labor (4e). Enter in (4f) the total actual indirect labor and determine effectiveness in the usual manner.

LINE 5
Determine **"TOTAL ACTUAL DIRECT AND INDIRECT LABOR"** (5f) by adding (3f) and (4f)

LINE 6
Record the standard ratio for supervisory and shop administrative functions in (5d). This ratio is the standard number of man-hours of supervisory and administrative work for every hundred man-hours supervised. Apply this ratio to the **"TOTAL ACTUAL DIRECT AND INDIRECT LABOR"** (5f) to obtain standard man-hours for supervisory and administrative functions (6e). Determine percent effectiveness for supervisory and administrative personnel in the usual manner. It must be recognized that this figure does not represent the effectiveness of supervision, but indicates variations in the supervisory and clerical ratio from standard. The true measurement of the effectiveness of supervision is indicated by the performance of the personnel supervised. In some instances, it may be desirable to separately measure supervisory personnel and administrative personnel. In these instances, Line 6 may be divided and separate entries made for supervisory and administrative or clerical functions.

LINE 7
Determine standard man-hours (7e) by adding (1e), (4e), and (6e). Determine actual man-hours (7f) for measured activities by adding (1f), (4f), and (6f). Compute shop effectiveness (7g) in the usual manner.

PERCENT COVERAGE
Determine percent coverage by dividing actual man-hours measured (7f) by grand total man-hours expended, which is the sum of the total man-hours measured and not measured ((7f) plus (2f)), and multiplying by 100.

FIG. 2 TYPICAL OPERATIONAL GROUP PERFORMANCE RECORD

ment were developed, however, for the production activities to be discussed.

MEASURING PRODUCTION ACTIVITIES

In developing the plan for the measurement and appraisal of production activities, each shop was treated as a distinct and complete production organization, carrying out its part of the arsenal mission by performing an assigned series of operations on an item of manufacture, without regard to other operations that may be performed by other shops within the arsenal.

This method, utilizing as its basis the measurement of elementary work done by production groups, rather than the quantities of finished items produced by the arsenal as a whole, made possible the establishment of valid comparisons of standard and actual man-hours. Moreover, it avoided the difficulties created by the large variations in volume of work in process which made it impracticable to measure performance on the basis of over-all arsenal production of end items.

Two objectives were constantly kept in mind:

1 That the necessary data for measurement be drawn from existing records and reports wherever possible, thus avoiding the introduction of any new reporting systems.

2 That the plan of measurement must meet the specific needs of the arsenal executives, from the top executive down to the shop foremen, in appraising their respective performances.

Measurement is applied to three classes of effort in the shops: (1) direct labor, (2) indirect labor, and (3) supervisory and administrative.

The measurement of performance of direct labor is based on a comparison of the actual direct labor hours expended during the month in a given shop with the corresponding standard labor hours. The ratio of the latter to the former is usually expressed in per cent and is called "effectiveness."

The standard labor hours for direct labor are the result of applying standard unit times for an operation or series of operations to the number of units of work processed in the shop during the month (see Fig. 2). The total standard labor hours is the sum of all of the standard labor hours for all classes of items processed by the shop during the month. This permits not only a determination of the over-all effectiveness of direct labor but, where desired, a similar determination with respect to each operation.

It was recognized that work of an experimental or research nature might be performed in each production organization, for which no standards which would be reasonably indicative of the manpower requirements could be established. Provision was made to permit separate reporting of direct labor hours expended on such work, thus providing merely a record of actual labor charges against those types of jobs.

Analysis of the indirect labor activities indicated that reasonable indirect labor ratios could be established which would permit month-to-month appraisal of that class of work. Indirect labor includes sweepers, movemen, elevator and crane operators, and other employees who are not directly chargeable to any one production job. The number of people engaged in these service activities was critically examined from the point of view of work load, and appropriate standards were established in terms of per cent of direct labor hours serviced. These standards, when applied to the total actual direct labor hours, including unmeasured work, provided the standard man-hours which should be allowed during the month, and which, when

June 1945

	MEASURED														
	DIRECT			INDIRECT			SUPERVISION			TOTALS			Total Non-Meas. Actual Man-Hrs.	Grand Total Act. M/Hrs	% Coverage
Section	Standard Man-Hours	Actual Man-Hours	% Eff.	Standard Man-Hours	Actual Man-Hours	% Eff.	Standard Man-Hours	Actual Man-Hours	% Eff.	Standard Man-Hours	Actual Man-Hours	% Eff.			
SA	7,660	7,308	105	2,915	2,996	98	1,544	1,520	102	12,119	11,824	102	343	12,167	97
SB	27,744	26,710	104	2,903	3,234	88	916	876	104	31,563	30,880	102	5,210	36,090	86
SC	6,243	7,461	84	3,145	3,110	101	980	791	124	10,368	11,362	91	214	11,576	98
SD#1	12,609	9,079	139	3,360	3,760	90	1,479	1,565	95	17,448	14,404	121	15	14,419	100
SD#2	2,585	3,029	85	1,108	1,014	109	1,065	979	109	4,758	5,022	95	222	5,244	96
SE	4,745	5,202	91	2,504	2,163	115	753	1,118	64	8,002	8,546	94	902	9,448	91
SH#1	13,760	15,690	88	8,450	7,711	109	1,610	1,829	88	23,820	25,230	95	248	25,478	99
SH#2	2,373	2,502	95	3,230	4,223	77	574	669	86	6,177	7,394	84	6,017	13,411	55
SH#3	1,329	2,461	54	920	1,488	62	665	732	91	2,914	4,681	62	2,510	7,191	65
SI	12,487	12,493	100	2,661	2,184	122	1,203	970	124	16,351	15,647	104	204	15,851	99
SJ	7,916	10,716	74	7,150	8,349	86	2,030	1,751	116	17,096	20,816	82	4,836	25,652	81
SK	22,003	23,817	92	22,472	22,480	100	4,598	3,711	124	49,073	50,008	98	19,399	69,407	72
SL	1,917	1,763	109	1,831	2,429	75	502	644	78	4,250	4,836	88	165	5,001	97
SN	3,972	3,639	109	2,762	2,223	124	984	1,148	86	7,718	7,010	110	4,492	11,502	61
SO	5,078	4,581	111	927	1,376	68	848	813	104	6,863	6,770	101	105	6,875	99
SQ	446	379	123	189	292	65	107	304	35	742	975	76	146	1,121	87
SR#1	3,602	4,021	90	770	1,319	58	610	718	85	4,982	6,058	82	368	6,426	94
SR#2	3,216	4,025	80	2,510	3,595	70	663	722	92	6,389	8,342	77	2,570	10,912	77
SU	7,786	9,323	83	1,915	2,369	81	425	382	111	10,126	12,074	84	1,601	13,675	88
SV	3,235	4,394	74	1,145	1,263	91	589	542	109	4,969	6,199	80	10	6,209	100
SY	3,400	4,071	84	930	1,314	71	890	1,561	57	5,220	6,946	75	357	7,303	95
SZ	1,705	1,997	86	573	773	74	321	404	82	2,599	3,174	82	1,369	4,543	70
Meas.-Mfg. Secs.	155,811	164,661	95	74,380	79,725	93	23,356	23,812	98	253,547	268,208	95	51,303	319,501	84
SP#4													2,355	2,355	0
SX				4,250	3,540	120	1,379	1,532	90	5,629	5,072	111	3,722	8,794	58
Non Meas-Mfg. Secs.				4,250	3,540	120	1,379	1,532	90	5,629	5,072	111	6,077	11,149	46
SF				1,553	1,960	79	2,255	2,121	107	3,808	4,081	93	4,313	8,394	49
[illegible]				355	348	102	898	1,016	88	1,253	1,364	92	3,729	5,093	27
SW3							226	176	128	226	176	128	2,049	2,225	8
SS							326	364	90	326	364	90	2,242	2,606	14
ST				2,080	2,331	89	1,781	2,009	89	3,861	4,340	89	17,034	21,374	20
SW							1,255	987	127	1,255	987	127	5,987	6,974	14
Perishable Tool Ser.				4,150	4,207	99	1,220	1,266	96	5,370	5,473	98		5,473	100
Gage Mfr. & Check Insp.													4,379	4,379	0
Service Sections:				8,138	8,846	92	7,961	7,939	100	16,099	16,785	96	42,723	59,518	30
S.A.A.D. Total:	155,811	164,661	95	86,768	92,111	94	32,696	33,283	98	275,275	290,055	95	97,113	387,168	75

FIG. 3 SUMMARY OF WORK MEASUREMENT: SMALL-ARMS AMMUNITION DIVISION

compared with the actual hours devoted to these service activities, result in a ratio of manpower utilization for that work. For reporting purposes only, this ratio is labeled "effectiveness."

SUPERVISORY AND ADMINISTRATIVE REQUIREMENTS

Similar reasoning was applied to the supervisory and administrative activities of the shop. This category includes personnel such as the foreman, assistant foreman, shop clerk, and others directly attached to the shop office. Overhead ratios were established to cover the work of this group in terms of the total direct and indirect labor hours supervised. The application of this ratio to the total labor hours supervised results in a standard supervisory man-hour requirement which, when compared with the corresponding actual hours expended, will give a figure indicative, in form of percentage, of the variations in the supervisory and clerical time from standard. It is recognized that this percentage does not represent the effectiveness of supervision, for the true measure of supervisory effectiveness is the performance of the personnel supervised.

In order to show the over-all performance of the shop as a whole, the standard hours and the corresponding actual hours are summarized and the percentage of the standard to actual hours is determined.

Since the plan does not prescribe the measurement of all work done and excludes special or experimental jobs, the effectiveness ratio for the measured effort of the shop as a whole would be meaningless unless it is related to the proportion of the total shop effort it represents. To give such ratios their appropriate significance, provision has been made to show the "coverage" attained in each production group. This is the total measured man-hours expressed in percentage of the man-hours expended in the entire shop.

The "Performance Record," Fig. 2, is designed to present a complete operating statement for any organizational group, showing:

1 The over-all effectiveness of direct labor on all items of work measured and, where desirable, its effectiveness on specific jobs.

2 A brief statement of unmeasured work done by direct labor, showing the man-hours actually expended.

3 The relation of standard to actual indirect labor hours.

4 The relation of standard to actual supervisory and administrative man-hours.

5 Over-all performance.

6 The coverage.

Data with respect to the amount of work done under each measured activity and operation, and expressed in terms of the appropriate units, are obtained each month without excessive bookkeeping. Production data are obtained largely from existing records maintained in connection with production control. Similarly, actual man-hour data for each activity or operation or group of operations are accumulated for each reporting period from basic time records maintained for cost and other purposes.

STANDARDS FOR ARSENAL OPERATIONS

Standards established for arsenals fall into two general groupings: (1) Common standards applicable to like activities carried on at all arsenals; and (2) special standards for those activities which are peculiar to each arsenal. These apply particularly to production operations which, as previously noted, are not comparable among arsenals.

Common standards have been established for practically all overhead and service activities which are considered comparable among arsenals. The standard man-hour requirements per unit of work for each of the overhead activities or operations selected for measurement were determined by analysis of experience data supplied by each installation performing such work. These man-hour data were arranged in ascending order, and the figure halfway between the best and the middle was

Control Approval Symbol 56

TO: Office, Chief of Ordnance Attn: SPOIX-Control	WORK MEASUREMENT RECORD	INSTALLATION Frankford Arsenal	
PREPARED BY A. M. Rohland, Statistical Clerk		OPERATING SERVICE Ordnance Department	SvC
APPROVED BY A. N. BOELL, Maj. Ord Dept. Asst. Control Officer	2 June 1945 to 29 June 1945 Incl. FOR THE MONTH OF ______ 194__	PERCENT OF TOTAL MAN-HOURS MEASURED [Col 5 ÷ (Col 5 + Col 7)] x 100	60%

Function	Work Unit	Number of Work Units	Standard Man-Hours	Measured Man-Hours Expended	Effectiveness	Unmeasured Man-Hours Expended	Number of People: Military Off.	Military Enl.	Civilian Total	Civilian Subj. Pl. 9	Other	Total Col. 8, 9, 10 & 12
1	2	3	4	5	6	7	8	9	10	11	12	13
Arsenal Total			1,022,498	1,152,127	88	871,608	242	247	12,002	3,104		12,491
Administration-Arsenal			24,710	34,099	72	10,149	5	4	245	193		255
Administrative	Arsenal Man-hour	2,119,543	8,266	6,772	122							
Janitorial	Thousand sq. ft.	137	4,488	5,156	87							
Management	None											
Print. & Reprod.	None											
Procurement	Document	1,708	11,956	22,171	54							
Other Adminis.												
Engineering							18	72	968	625		1,058
Laboratory	None											
Materiel Engin.	None											
Plant Engineering	None											
Repairs & Maint.	None											
Fiscal & Finance				1,795			1		29	29		59
Cost Accounting	Order	1,835	2,110	1,795	118							
Fiscal	Multiple					3,032						
Inspection			55,028	69,711	79	77,087	1	5	920	189		926
Acceptance Testing	Multiple		54,316	69,003	78	10,117						
Administrative	Insp. Man-hour	79,120	712	708	101							
Gage Insp. & Control	None					66,970						
Maintenance			5,760	4,684	123				27			27
Office Appliance	Appliance Repaired	468	431	454	95							
Vehicle	Multiple		5,329	4,230	126							
Manufacturing			827,820	922,225	90	156,520	21	38	7,060	316		7,119
Administrative	Mfg. Man-hour	1,033,530	41,341	45,215	91		14	10	236	191		260
Prod. Plan. & Sched.	Expend. Order, etc.	995				20,563			111	83		111
Production	Multiple		782,605	877,010	89	135,957	7	28	6,713	42		6,748
Small Arms			275,275	290,055	95	97,113						
Artillery			284,386	363,591	78	35,088						
Instrument			222,944	223,364	99	3,756						
Personnel - Civilian			34,074	48,603	70	8,148	1		348	283		349
Civilian Payroll	Civ. Man-hour	2,017,457	16,947	23,019	74							
Personnel Admin.	Civ. Man-hour	2,014,892	17,127	25,584	67							
Other Personnel	None					8,148						
Property			71,833	67,790	106	15,987	1		455	142		456
Major Warehousing	None					1,252						
Property Disposal												
Administrative	Line Item	1,769				7,086						
Salvage	Multiple					7,649						
Rec., Stor., etc.	Ton	36,027	54,041	56,524	96							
Stock Records	Prop. Vouch. Proc.	26,165	17,792	11,266	158							
Safety & Security						42,809	1		248	248		249
Admin. & Intell.	None					3,543						
Fire Prevention, etc	None					7,158						
Interior Guard	None					27,714						
Plant Safety	None					4,394						
Transportation			3,363	3,220	104				28	28		28
Commercial Traffic	Bill of Lading	5,020	3,363	3,220	104							
Rail Operation	Car Spotted	None at the Arsenal										
Miscellaneous						348,228	193	128	1,673	1,051		1,994

NOTE: This report excludes activities which are the responsibility of the Service Command.

FIG. 4 WORK-MEASUREMENT RECORD FOR ENTIRE ARSENAL INSTALLATION

selected as the standard. Some overhead activities, such as those falling within the general category of "Repairs and Utilities," are performed under conditions reasonably common to installations in Quartermaster, Engineers, and other elements of the Army Service Forces, as well as Ordnance. Accordingly, the standards for such activities are based on the experience of many installations. On the other hand, standards for operations such as "Production Planning and Scheduling" are based on the experience of the arsenals because they are common only to those installations.

Standards for production work are set by each arsenal for each elementary operation performed in connection with the production and assembly of the various parts required for the manufacture of the assigned end items. While the useful tool of management, stopwatch time study, is not permitted by law in Ordnance arsenals, adequate time standards have been set for all operations, either through the analysis of experience data with respect to labor cost, or by determining them synthetically from knowledge of cuttng tools, machine feeds and speeds, estimating for the manual elements involved, and making appropriate allowances for fatigue and personal needs. All operations required for the production of an item are not necessarily measured separately. Usually, a single standard of time was established for all operations performed on a given item in any one shop.

These are drawn largely from "route sheets," which show for each piece to be produced, the various operations required, their sequence, the production organization involved, the standard man-hours for each operation, and other pertinent manufacturing data. The number of units produced, in this case, would be the number of pieces on which all of the assigned operations are performed by that shop.

Where an item requires a long series of operations within a single production group, with the possibility of abnormal variations in the amount of work in process from month to month, the entire series of operations is broken down into two or more groups, each ending at a key inspection point, at which a count of the units processed is available from inspection records. The over-all standard time for the complete series of operations is then broken down to component standards corresponding to the two or more groups of operations thus established. This procedure eliminates inaccurate portrayals of true performance caused by extreme fluctuations in month-end inventories of work in process.

MEASUREMENT AS A TOOL OF MANAGEMENT

The measurement of performance is serving as an effective tool of management in providing factual data for the appraisal of the effectiveness of operating groups from a shop or an office with a relatively small group of employees to divisions embracing as many as 30 operating groups and involving the work of thousands of people. Each supervisor and executive is given information each month concerning the performance of his group, thus providing him with the means of evaluating his performance. In case of production shops, the foreman receives a copy of the performance record covering the work of his group.

These performance records are also summarized to present a picture of performance for the combined operations of an entire manufacturing division (see "Performance Record Summary," Fig. 3). These summaries provide a quick picture for a division chief of the over-all effectiveness of the various organizational units under his command and enable him to spot those operations which require his attention either to commend outstanding performances or to take remedial action to correct poor performances of direct labor and abnormal variations in indirect labor and supervision from established norms.

All such actions are aimed at keeping the manpower of the organizational units at a level commensurate with the work load being handled and consistent with standard performance.

The process of grouping records of performance is carried to the preparation of an over-all report, thus enabling the commanding officer to appraise the performance of the entire installation. This report, designed for top management, covers the major activities of the installation and provides a valuable tool for managing on the exception principle (see Fig. 4). Substandard performances are invariably discussed at conferences of the commanding officer and his key personnel, who are in a position to judge the performance of the installation on their special production activities, as well as on those activities comparable to other arsenals.

Besides permitting continuing scrutiny of effectiveness of manpower utilization, the three reports described also serve as an effective means of determining personnel requirements. The standards of man-hour requirements for the various units of work, when tempered by the performance attained, are used to synthesize labor costs for items involving new combinations of operations. They further provide a sound basis for the establishment of manpower needs to meet anticipated work loads.

The foregoing reports and standards are used for this purpose at all levels, particularly by the foremen of production groups when they are asked to submit personnel requirements for new schedules of production. In addition, examination of the performance records by the foremen has often resulted in recommendations to higher authority in the arsenal to reduce personnel wherever low effectiveness indicated an excess of personnel.

ACKNOWLEDGMENT

The methods of measurement described in this paper were developed by the author with the assistance of Major Lester Schreiberg, Control Division, Office, Chief of Ordnance, and the collaboration of Ordnance arsenal personnel and personnel of Industrial Service, Office, Chief of Ordnance.

Measurement of Surface Roughness

(*Continued from page 306*)

It was mentioned that $\frac{d^2y}{dx^2}$ only approximates the degree of curvature. The error increases as the slope $\frac{dy}{dx}$ increases, being zero when y' equals zero, and not exceeding 3 per cent until y' is greater than 1/10. Much experimental work will be required before it can be decided whether the values not accurately representing the degree of curvature should be corrected or filtered out. Such a procedure would not be necessary to insure statistical similarity, but might be desirable in order to obtain better correlation with the results of physical tests. It should be noted that y'' approximates the degree of curvature most accurately through the tops of the peaks and the bottoms of the valleys, locations where sharpness of curvature is likely to have greatest influence in roughness phenomena.

The roughness of a surface cannot of course be represented by a profile along a single line unless the surface is entirely free from "grain." If directional characteristics are present, profiles should be taken along and across the grain. The difference will appear only in the slope and curvature distributions.

CUTTING FLUIDS

An Appraisal and an Apology

By WILLIAM H. OLDACRE

PRESIDENT, D. A. STUART OIL COMPANY, CHICAGO, ILL. MEMBER A.S.M.E.

THE development of cutting fluids has been contemporaneous with and has in no small measure contributed to the development of the modern high-speed metal-cutting machine. Probably the earliest metalworking processes involved the occasional use of some fat or fluid as a lubricant, but cutting fluids received little special attention until the last half of the nineteenth century brought to a high degree of perfection the slide rest, the turret, and other contributions to continuous high-speed metal-cutting. When flow systems replaced the oil can, the brush, and the drip can, the functions of the cutting fluid began to attract attention and challenge explanation.

Under such circumstances, it might reasonably be expected that the literature of the period of nearly one hundred years would throw much light upon the function and composition of cutting fluids. However, even a casual investigation will show a continuing ambiguity and seemingly careless if not studied indifference to clear identification and definition in dealing with this subject. This attitude is difficult to explain except as we appreciate the complexity and the intricacy of the metal-cutting process and realize that in this field, as in so many others, man's accomplishment so completely outruns his understanding. In times of rapid development, the investigator is apt to be occupied fully with his own particular interest and have little time for more than a speculative analysis of associated phenomena.

W. Henry Northcott in a treatise (1)[1] on the subject of lathes and turning, in 1868, writes as follows:

"Lubrication makes a great difference in the power required to drive the lathe against a certain cut, the work is much smoother and the work and tool being kept cool a much faster circumferential speed is feasible without injury to the tool.

"The heating of the tool and work besides doing the former an injury is a positive waste or loss of power, as for every unit of heat produced 772 foot-pounds of power are lost.

"The lubricating liquids are various. Oil is good but expensive; soapsuds are also much used, but perhaps a solution of common soda in water is as good and cheap as anything. A little dirty oil or oil that has run through bearings may be advantageously mixed with the soda water. Water, if used alone, would cause the work and the lathe to be covered with rust half an hour after using. The addition of soda water not only softens the water but to a great extent prevents its rusting the metallic surfaces . . . the soda water supplied through small flexible tubing from a pipe overhead should be caused to drop just on the cutting point of the tool or where the tool engages the cut.

"It should not be niggardly supplied, not only because it is inexpensive, but because it can be partly collected in a tray placed under the tool and returned again to the reservoir."

This discussion patterns the treatment of the subject from that day to this. The ambiguous reference to "oil," and the lack of quantitative information on the "soapsuds" and "soda water," are paralleled in current literature by easy references to "sulphurized" and "soluble oils."

ACCURACY IN DEFINING CUTTING FLUIDS NEEDED

It is high time that the complexity of this subject be appreciated and the need for more accurate definition and classification of cutting fluids be recognized. Researchers should identify materials used as accurately as possible, using trade names if no other means of positive identification are available. However, such a course will rarely be necessary if full advantage is taken of known test methods and information. For, as is the case in the reference given, it is not the unknown but the carelessly or willfully by-passed information which handicaps our full understanding. Certainly Mr. Northcott knew or could have easily ascertained the fact that a little "dirty oil" (fatty oil in use at the time for lubricating purposes) added to soda water would saponify and produce a soap solution or emulsion.

The use of such mixtures of fatty or fatty-mineral oil compounds (2) with soda water continued until World War I, and as late as 1910 there was much argument as to whether they should be "boiled" or "unboiled." Obviously, the amount of boiling would determine the degree of saponification and whether the end result was a soap solution or a partial emulsion or unsaponified fat.

The conflict between coolant and lubricant ideologies is early apparent and discussion then as now took refuge in words to cover a nearly complete lack of understanding of the functions indicated. All attempts to classify cutting fluids on the functional basis are seriously hampered by ignorance of the mechanisms of lubrication, chip formation, and heat transfer. Scarcely any better is our knowledge of physical and chemical properties as related to this subject. Even in the field of observed performance in the shop, there is so much that is contradictory and so little that is well documented. Most factory observation is at the operator level and can scarcely be expected to meet the requirements of scientific analysis.

THREE-PHASE EMULSIONS

There is, however, much pertinent information which is readily available and easily verified. First, with respect to the so-called "soluble" oils ordinarily casually described as coolants, they are in fact intricate colloidal systems with widely differing characteristics, and with lubricating, rust-inhibiting, and other variable and more or less desirable qualities. The simplest stable emulsions are three-phase, in which the outer phase may consist of a soap and salt solution while the inner or dispersed phase consists of oil and possibly soap. For the purposes of this paper it is assumed that the protective phase

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[1] Numbers in parentheses refer to the Bibliography at the end of the paper.

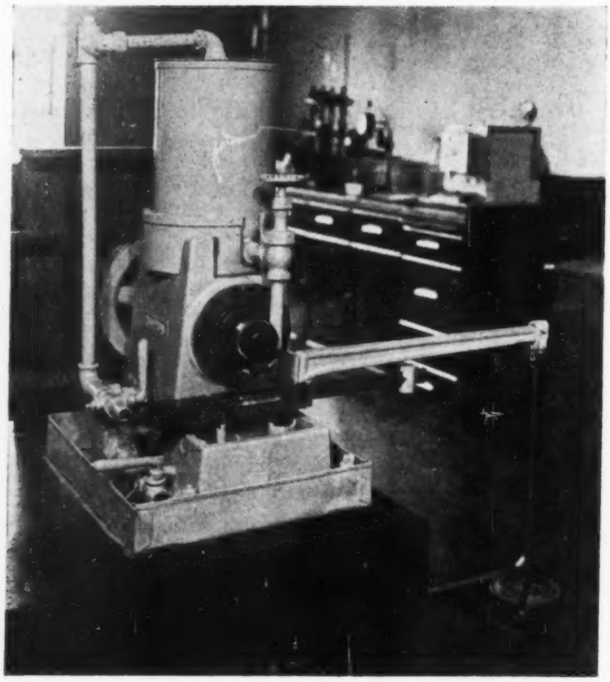

FIG. 1 TIMKEN LUBRICANT TESTER

serves merely to maintain the emulsion. The outer phase may vary widely in concentration and in type of soap. It probably has much to do with the surface-wetting and rust-inhibiting properties of the emulsion. While most soluble oils contain an excess of organic acid, their emulsions are almost always alkaline due to the hydrolysis of the soaps in solution in the outer phase. The inner phase of the emulsion may be neutral petroleum, fatty oil, or mixtures, or may contain a wide variety of oil-combined additives.

Toward other substances an emulsion behaves according to its outer phase. Thus an oil-in-water emulsion water-wets a paper test strip while a water-in-oil emulsion oil-wets it. On this basis an ordinary emulsion would be expected to act like a dilute soap solution, and in fact does so, except that at the high temperature prevailing at the tool point the emulsion probably breaks down, setting free a certain amount of free oily lubricant.

Not all soluble oils are simple three-phase mixtures. The dispersed phase may itself be a water-in-oil emulsion or a certain amount of free oil may be loosely suspended in the emulsion. It is a reasonable assumption that such differences in oil content will affect the behavior of the emulsion as a cutting fluid, and this fact is easily verified by experiment.

Customarily, considerable emphasis is placed on the uniformity and stability of an emulsion. While obviously any instability which results in variable performance is undesirable, a certain amount of oily separation frequently benefits operations requiring increased lubrication or cutting quality. Presumably the free oil is simply carried by the emulsion to the tool-point area where it functions as a straight cutting oil. A dispersed water-in-oil emulsion behaves in a similar manner. The presence of a water-in-oil emulsion is evidenced by "creaming" and is a common characteristic of soluble paste compounds."

The fact that the outer phase of an ordinary emulsion is a soap solution accounts for the rather peculiar cooling characteristics of such cutting fluids. Below the boiling point they are efficient coolants, comparing favorably with plain water but above the boiling point they are poor coolants, probably due to the formation of a steam foam blanket which insulates the hot surface. The rapidly increasing use of oil as a grinding fluid on high-velocity "thread-grinding" operations is due to the fact that better cooling at the "hot spot" helps prevent wheel breakdown and reduces grinding checks by reducing extreme differences in temperature between the area of contact and the cooler parts of the workpiece.

An emulsion is a delicately balanced system and anything which upsets the equilibrium is apt to affect performance. Therefore, when such materials are tested or evaluated on the machine, great care must be exercised to prevent contamination or change. That fatty materials picked up from machine lubricants, rust-preventive compounds, or carry-over from previous operations may actually improve performance under some conditions does not make such contamination any more desirable when testing.

The assumption that water-mixed cutting fluids are but water plus a rust inhibitor has been persistently promoted for nearly a hundred years, but the facts of performance have consistently belied it.

STRAIGHT OIL CUTTING FLUIDS

Turning to straight oil cutting fluids, an equally complex and confusing problem of description and classification is encountered. However, investigation discloses certain strongly evidenced truths: (*a*) The most obvious is that not all lubricating oils are good cutting fluids; (*b*) that there is some relationship between chemical activity and cutting-fluid performance; and (*c*) that more than one function may be involved in the lubricating process, especially under conditions of so-called boundary lubrication or those where metal-to-metal contact is involved. Extreme-pressure lubricant-testing machines have been most helpful in the study of lubricants functioning under heavy load conditions. Developed for the investigation of gear lubricants, the five generally accepted machines all rate lubricants on the basis of seizure or scuffing of metal test parts in moving loaded contact.

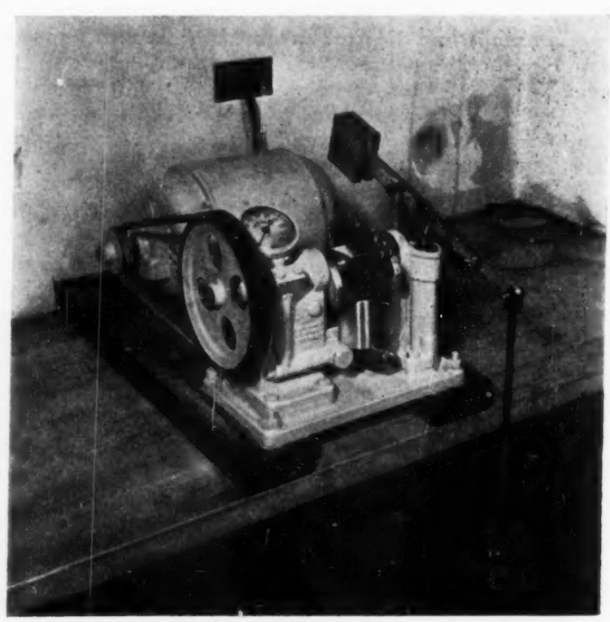

FIG. 2 ALMEN LUBRICANT TESTER

LUBRICANT TESTING MACHINES

The Timken lubricant tester (3), Fig. 1, one of the first developed, presses a fixed test block against a revolving ring by means of a lever-and-weight system. Both test block and ring are carburized, hardened, and ground to a 25 to 30-microinch finish. The speed is constant at approximately 400 rubbing ft per min, and the load is regularly increased by the addition of weights to the lever arm. (Lubricant flows from a reservoir over the cup and block and is returned from a sump by a pump.)

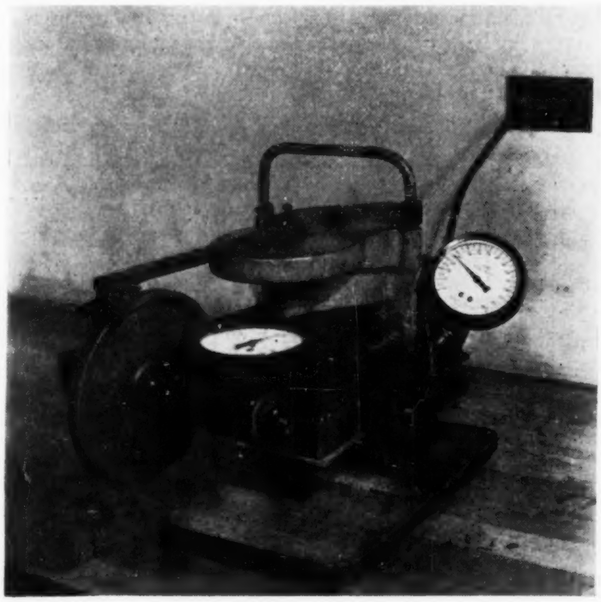

FIG. 3 FAVILLE-LE VALLY LUBRICANT TESTER

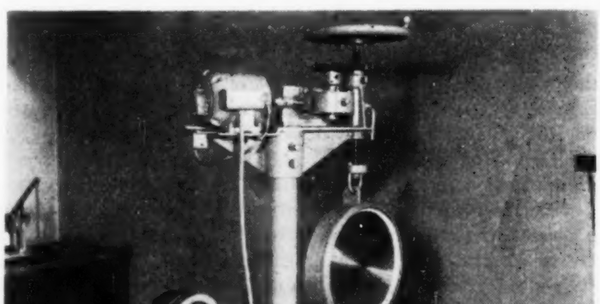

FIG. 4 S.A.E. LUBRICANT TESTER

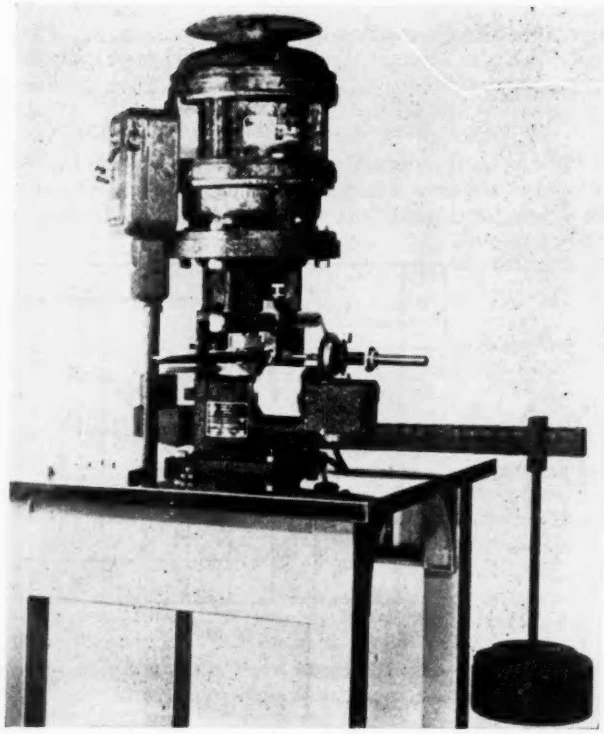

FIG. 5 SHELL FOUR-BALL EXTREME-PRESSURE LUBRICANT TESTER

Results are stated in terms of load at time of seizure. The width of wear scar on the block is often noted as an index of wear. A second lever intended for torque determination has never been too successful and is little used.

The Almen machine (4), Fig. 2, developed in the General Motors research laboratory, uses a hydraulic clamp to squeeze two halves of a split bushing on a driven pin. Load weights are applied to a lever arm operating a piston in a cylinder, connected hydraulically to the clamping cylinder. The clamping assembly and lubricant cup are pivoted to revolve freely about the axis of the pin. By means of a lever and a third hydraulic cylinder connected to a pressure gage, a friction or torque reading is obtained. The lubricant under test is in a small cup surrounding the test parts and results are given in terms of load against torque and load at seizure. Test parts are usually hardened $^1/_4$-in. drill rod against soft-steel bushings.

The Faville-LeVally or Falex tester (5), Fig. 3, is similar in principle but uses two V-shaped test blocks instead of the split bushing, and the load is applied by means of a calibrated spring and a pawl-actuated screw and nut. It also gives a torque reading by means of a sylphon bellows and pressure gage.

The S.A.E. machine (6), Fig. 4, designed to simulate a one-tooth gear, uses two rings revolving in contact at different speeds and loaded by means of a motor-driven screw-and-lever system. A scale dial indicates the load. The lubricant is placed in a cup enclosing the lower low-speed ring. Both rings are hardened and ground to a 25 to 30-microinch finish, and results are stated in terms of load at seizure. Speed, loading rate, and rubbing ratio are variable.

The Four-Ball machine (7), Fig. 5, while one of the earliest developed, has only recently received much attention. Four $^1/_2$-in. steel balls are used as test parts. Three are held stationary, locked in a ball pot; the fourth is rotated while pressed

against them. The ball-pot assembly is free to rotate about the vertical axis of the machine. The lubricant under test is held in the ball pot. Frictional torque is recorded graphically on a drum and related to load.

FUNCTION OF SULPHUR AND COMPOUNDS IN LUBRICANTS

All tests on these machines point definitely to the function of sulphur and certain sulphur compounds as antiweld agents. They also distinguish sharply between the functioning of sulphur and that of other additive compounds, Fig. 6. For instance, oils containing sufficient active sulphur will prevent seizure between the rings on the S.A.E. tester even though the rings become red-hot due to friction and load. Contrarily, oils containing active chlorinated compounds will retard the rate of heating and to that extent will prevent welding, but immediately the temperature reaches a critical level, seizure ensues, Fig. 7.

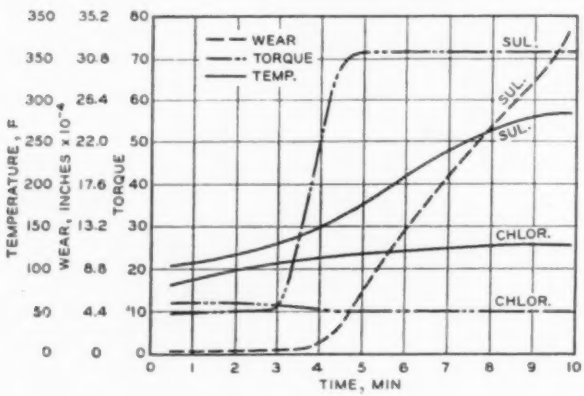

FIG. 6 WEAR, TORQUE, TEMPERATURE, TIME RELATIONSHIP FOR SULPHURIZED AND CHLORINATED OILS

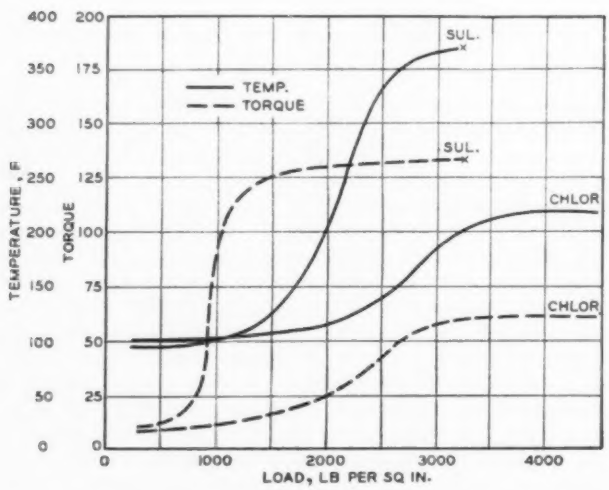

FIG. 7 TEMPERATURE, TORQUE, LOAD RELATIONSHIP FOR SULPHURIZED AND CHLORINATED OILS

Thus test rings after a run with sulphurized oil will be discolored and softened but will show no scuffing or evidence of welding; while those run with chlorinated products will be bright and show no softening or temper color, but will be badly scuffed and welded.

Further, on the Almen or Falex machines, where torque readings are possible, sulphurized oils will give very high torque readings with no seizure, while chlorinated oils will show very low torque but will seize when the critical point is reached. Such results point to differences in function which merit much more attention than to date has been accorded them.

Another interesting observation is the increased rates of "wear" with oils of high sulphur activity. Scar width on the Timken block indicates a wear rate several times greater than that of sulphur-free oils.

As previously mentioned, the lubricant-testing machines were developed to aid in the evaluation of gear lubricants and have not received merited attention from investigators and users of cutting fluids. It is not suggested that they afford a means of direct evaluation but they do throw light on many baffling cutting-fluid problems.

Test parts and test conditions as presently constituted are assumed to correlate with gear-lubricant requirements, but obviously these may be varied over a wide range and thus be brought more nearly in line with metal-cutting needs.

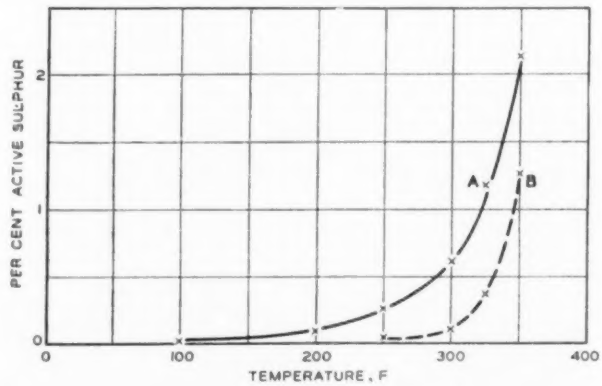

FIG. 8 SULPHUR ACTIVITY VERSUS TEMPERATURE OF TWO TYPICAL COMMERCIAL SULPHURIZED OILS

Sulphur and sulphur compounds as antiweld agents in cutting fluids are widely accepted and generally appreciated. However, it is not so clearly recognized that only a limited number of sulphur compounds are effective and these differ greatly in antiweld efficiency. The "total sulphur" (8) content of an oil, as determined by the usual laboratory methods, tells little of value. Part or all of the sulphur may be neutral or inactive. Several "active-sulphur" tests which are tentatively accepted depend upon the reaction between metallic copper and reactive sulphur or sulphur compounds (9). While the results of such tests cannot be taken as conclusive, they are indicative and helpful, Fig. 8. Some work has been done with similar tests using other metals than copper, and it appears that this is a promising field for further investigating.

CORRELATION BETWEEN LABORATORY AND SHOP

Improved correlation between laboratory and shop is imperative. As has been mentioned before, most shop observation is at the operator level. Rarely is a trained engineer assigned to observe and record operating results, and even more rarely is adequate time and assistance allocated to this important job.

The purveyor of cutting fluids is usually accused of neglecting basic facts and dealing in hyperbole and high-pressure salesmanship. Perhaps there is more than a little basis for this accusation, but it must be kept in mind that he is working

in the shop, his products must meet the tests of actual operations, and he is largely dependent for evaluation and acceptance upon the opinions of operators untrained in scientific appraisal. When management becomes properly interested in this job and assigns adequately trained personnel to observe and report on the details of machine performance, it will undoubtedly be discovered that the cutting-fluid engineer is right with them plugging for progress.

THE APOLOGY

When the magnitude and the possible profits of our job are appreciated, it will appear that an all-round apology is due from all concerned for our long delay in getting together, and as a cutting-fluid engineer and salesman, I would like to introduce an era of closer co-operation between all the elements that contribute to this great metalworking industry by presenting my apology right now.

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Appendix

ACTIVE-SULPHUR DETERMINATION

General Motors Copper-Powder Method.[2] Weigh 100 g of the lubricant and 20 g of copper powder (Baker's precipitated copper) into a 200-cc flask equipped with a glass stirrer. Heat the lubricant containing the copper powder to 350 F in 5 min and maintain at 350 F, with constant stirring for 1 hr. Remove the copper from a portion of the lubricant by filtration and determine the sulphur in the filtrate by A.S.T.M. Method D-129-34. Determine sulphur in a blank, following exactly the method described, except that no copper powder is added to the lubricant. (If the lubricant contains sulphur compounds that are volatile at 350 F, the sulphur in the blank may be less than the total sulphur.) Subtract per cent sulphur, determined when copper powder is added, from per cent sulphur, determined in blank, and report difference as "active sulphur."

[2] From "General Motors Standards," published for information of General Motors Car Lubrication Committee, vol. 2, March, 1939, p. D-6.

The Ter Meer Continuous Centrifugal

(*Continued from page* 332)

OPERATING SUGGESTIONS

One thing which is essential to satisfactory operation of the machine is a uniform feed, and this should be as uniform as possible in both quantity and composition. Variations in quantity within the capacity of the machine result in variations in retention time and consequently in the moisture content or degree of wash obtained on the discharged salt. If the quantity fed exceeds the capacity of the machine, slurry will back up in the funnel and cause the machine to vibrate badly, or it may develop enough pressure to flood out under the leveling ring and wash out a section of the cake which will of course cause very heavy vibration and out-of-balance stresses. The same thing may happen if the slurry becomes almost all mother liquor as the screen may not be able to drain off the liquor which will then build up and finally wash out a section of the cake.

No one feeder is applicable to all slurries. In many cases a cone-bottom tank located directly above the machine with a short feed line, using a plug cock for throttling, is satisfactory. In another, an adjustable-stroke diaphragm pump gives excellent results. In still another, an overflow with an adjustable weir works satisfactorily. The ideal feeder should deliver a definite volume of slurry for each stroke of the pusher, and if possible be so connected that it stops feeding should the pusher stop. In addition, a settling tank or other means of obtaining a uniform high concentration of solids should be provided.

For smooth operation a uniform cake must be maintained in the basket. In most cases uniform distribution by the funnel and uniform drainage leave very little work for the leveling ring to do, and almost nothing for the operator. However, in some cases, the cake may not build up to the leveling ring and it will be necessary for the operator to reduce the frequency of the pusher until it does. This is accomplished by changing the setting of the flow control.

Most materials which can be handled in this machine will discharge readily, although occasionally one is encountered which will tend to stick in the dry housing and, in these cases, oversize housings, vibrators, or rubber diaphragms may have to be resorted to.

MANY PRODUCTS HANDLED

The ter Meer continuous centrifugal is being used successfully to handle a wide variety of products both in this country and abroad. A few of these are ammonium sulphate, ammonium nitrate, calcium nitrate, cellulose acetate, Glauber's salts, hexamine, paradichlorobenzene, caustic soda, citric acid, cotton linter, potash, and table salt. As stated, the use of the machine is limited to the separation of relatively coarse, free-draining solids from a liquid, but, within these limitations it handles large quantities of material with a minimum of floor space, power, operating labor, and maintenance.

LABOR RELATIONS *in the* TEXTILE-ENGINEERING FIELD

By J. J. McELROY

GENERAL SUPERINTENDENT, MAVERICK MILLS, EAST BOSTON, MASS. MEMBER A.S.M.E.

THERE was a time when management could purchase any type of machinery and equipment and operate it as seemed desirable. The engineer who sold it, or the management that purchased it, seldom considered the acceptance of the new working conditions by the employees to be a problem.

During the last five years there has developed a strong labor resistance to former ways of introducing new methods and machinery. Labor is demanding a voice, and has become a factor in engineering changes that must be recognized by the engineer.

Management is forced to consider the new factor at the very beginning of a contemplated change. The decision to go ahead now involves less return on the new capital investment, more risk and time to get employee acceptance, and generally results in workers profiting for a higher earning capacity. This means that every new installation, involving changes in duties and tasks, must be engineered carefully and examined from a labor-relations angle.

This development is discouraging to the purchase of new machinery. Among the risks involved is that the employees will not operate the new equipment at the desired job load and rates that were figured to justify its purchase originally. It is easy to see where an investment in new equipment might not produce the lower unit cost that was figured and expected because of labor interference factors that had not been considered at the start. Therefore, it would seem that the management of textile mills must become more engineering-minded, and the engineer must learn more about the functions of manufacturing management and have a deeper knowledge of the problems involved in the present-day relationship of the machine to the worker.

All phases of engineering in the textile industry are going to be more or less affected by the power and control of the unions. The worker today is selling his services. He is in a position to bargain, and as a result organized labor is a factor in the purchase and design of the more modern improved machines, and has considerable to say for its success or failure.

It might be well at this point to state briefly that the engineers and managers who are connected directly or indirectly with the textile industry should be familiar with the basic policies of the organized-labor movement.

When all the factors in modern society are considered, unions and collective bargaining are logical reactions. They are human force reactions and are directly related to the machine. It is of course true that labor movements are basically political and their leaders are not much concerned in the engineering approach to solutions, but as time goes on, and if our society is to survive, they too must recognize the value of scientific approach to the problem. There are some unions that do not believe the interests of society are best served by coordination of capital and labor, and even in conservative unions the struggle for power and control is producing results on management functions that are developing poor control and discipline in the industrial structure.

One extreme left-wing union has made the following statement: "We believe that the interests of labor and capital are in direct opposition to each other and that gains to one mean losses to the other. We believe that there is a continuous struggle going on between capital and labor, and that a labor-union contract under which workers are employed is a temporary truce in a continuous war."

The textile manager and engineer must recognize the force of this statement. It cannot be totally disregarded. Right or wrong, it becomes a factor in any new engineering job study. The primitive declaration in the first part is the same doctrine practiced by the industrialists in the "gay nineties" period. The second part undoubtedly is a truism.

All unions actually practice this policy, and there does and will continue to exist conflict between management and the worker on the question as to how much effort the worker will contribute and what he gets in return for this effort. It is a natural reaction, and can be settled intelligently by the workers and management if they agree to orderly fair procedures, and if the union will recognize the necessity of discipline within the organization.

The problems created by collective bargaining are really only begun when a contract is signed by both parties. Modern contracts involving work-load clauses, piecework provisions, grievance procedures, and seniority become quite complicated and technical in actual practice. In the everyday running of the mill, technical labor problems come up that only a few years ago would never occur. Management and the engineer are now forced to consider details brought up by labor on day-to-day conditions that they ignored in the past.

Most managements and engineers feel quite annoyed by the amount of time that they must now allot to human relations. They do not like this unknown factor, and yet they must learn how to handle it. If we start thinking of organized labor as a force factor, recognizing the mixture of human reactions that go into the effort output, we will then approach the problem on a practical realistic basis.

The new worker is quite intelligent. Better leaders are being developed, and the sane answer is a more orderly scientific approach to the problem that will produce more responsibility in the ranks of labor and better understanding of the methods used to value human effort by all involved. This approach is only in its infancy, but we have already found out that we must, under the collective-bargaining system, think more and more analytically and work out rules and formulas to fit this relationship between the machine and the worker.

TEXTILE INDUSTRY LAGS IN LABOR RELATIONS

The textile industry has lagged behind other industries. The general low wage paid in the textile industry tended to discourage mechanical development and methods improvement, and

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today the northern industry finds itself on the spot with the following two problems among others: (1) To maintain existing work loads; (2) to improve methods and reduce unit costs.

To meet these new conditions and operate successfully, the management structure from the president down to the foreman must become more engineering- and labor-relations-minded. Labor must recognize management as a function that must have clear lines of control extending through to the foreman level to insure discipline within the organization. Without discipline and control, all our research and engineering developments cannot be satisfactorily and profitably put to work for the good of all concerned—owners, management, and labor.

There must develop out of sheer necessity a clear understanding between operating executives and workers in regard to responsibilities of each other, as today we find all around us a breaking down of normal controls which results in confusion and inefficiency. As a result of the rapid growth of labor organizations using every tool within their reach to expand and guarantee their own security, they have encouraged disregard of discipline that insures orderly procedures and control. This process of breaking down management control and discipline in various unnecessary ways will and has produced a disregard for discipline in general, and may well turn out to be the Frankenstein that will injure seriously the union movement.

Problems of labor relations might seem far afield to some engineers, but they certainly are troublesome everyday considerations to most managements in the textile industry. The fundamental problem is to learn how to get along with labor under the new rules, and maintain a position of control which enables the management to improve its product and to lower costs; to put into effect and secure a fair trial of new machinery and methods. There is little object in spending funds for improvements if labor will not co-operate and recognize the necessity for clean-cut managerial direction which is so essential to make any improvement work out according to plan.

GRIEVANCE CLAUSE PUTS MANAGEMENT BEHIND THE "EIGHT-BALL"

A good example of the difference in thought between management and labor is found in the grievance clause. The union's first step in this clause places the management function right behind the "eight-ball," and is the type of regulation that prevents management and engineer from operating efficiently. This first step is a most important matter and is discussed in detail as follows:

Management recognizes the need for grievance procedure and agrees with the union except for one little inconspicuous paragraph. The standard union contract reads as follows:

"Should an employee have a grievance an honest effort should be made to adjust such grievance immediately in the following manner:

"Step 1. Between a member, or members, of the Shop Committee accompanied by the aggrieved employee and the foreman of the department."

Management wants it to read:

Step 1. Between the aggrieved employee and the foreman of the department.

The next two or three steps are accepted without quarrel by both union and management, and give all the necessary machinery to overrule any foreman's decision. Step 1 should be a hard and fixed rule that any individual must first take his case up with his immediate superior, "the foreman," and no grievance exists unless the matter cannot be adjusted satisfactorily. If carried further it then establishes the case, the time, and the facts.

Management wishes it written to establish a clean starting place for grievances and the retention of direct contact between the workers and the foreman. Management desires that all matters be first referred to the foreman so there will be no loophole or possibility of routine everyday requests and complaints, which are strictly in the line of foreman's responsibility, being passed on first by an elected steward in the department. Frankly, management wishes the foreman to have direct control and a clean line of authority and responsibility to exercise it within certain limits.

The union desires a much more flexible system by which all matters must first be handled through the department steward. They of course say only grievances, but the matter is much deeper than that as under the union clause the steward would have to handle and pass on many cases that are basically not the subject of a grievance which could have been settled directly with no loss of time if brought directly to the foreman.

The conflict of opinion on this first step therefore resolves itself into the relative importance of the foreman and the steward in the department. Under the union clause, the position of the steward may be built up so it can result in having two bosses in the same department, with the resulting conflict and lack of harmony that will always be present when there is not a clear line of responsibility and duties between the foreman and the steward.

FOREMEN IMPORTANT FACTORS IN MANUFACTURING SETUP

In the course of a month each foreman has to discuss, settle, and adjust hundreds of various small matters, requests, and complaints in direct contact with the workers. The few that cannot be settled become formal grievances, and in the resulting negotiations the foreman will be proved either right or wrong. The foreman holds an important position around which manufacturing success is maintained, and at this critical zone of control contact there should be rules and regulations that permit him to function with minimum friction and maximum co-operation between himself and his employees. Elimination of this direct contact will produce a weaker foreman system, which in turn will produce inefficiency, poor control, and poor discipline. If management and the foreman are held responsible for results there should be fair conditions to operate under, and the duties and functions of the steward should be clearly limited to the handling of grievances which can be properly placed, defined, and valued.

Incidentally, management and capitalism mean the same thing to most people. They forget that management is a function that is used by any system, and the weakening of this function of control is not a sound correction to improve the status of the workers, particularly in its elementary stages as represented by the introduction of additional complications in the relationship and duties of the foreman and the steward.

Under the first step as follows: "Between the aggrieved employee and the foreman of the department," there is a healthy clean line of foreman and steward relationship. The foreman has the opportunity to discuss any matter direct with the employee. The burden of handling dozens of requests, complaints, and various other troubles, both mechanical and personal, are clearly the foreman's duty. There is little cause for jurisdictional disputes as to what is, and what is not, the function or duty of the steward to handle.

Looking at the matter from any viewpoint, this difference of opinion on the first step is important. In substance the union formula means: (1) That the steward has the sole power to originate a grievance, and that a grievance may be almost anything. (2) That an individual worker may not express himself except through the medium of a department steward. (3) That the steward may question every action and decision of the foreman and, through political power, force management to discharge foremen who do not play ball the steward's way. The result is that the management's number-one contact with labor

at the critical point of department or section control is subject to strong, union, political domination. The resultant inefficient compromises would never develop if the first step were clean-cut as management desires.

Some mill executives are little concerned. They say, after all, if handled to prevent any decisions occurring in the first stage it means nothing, as the general effect of the Wagner Act has been to restrict foreman authority and force management to handle even small matters in a semilegal way beyond the first step—so why fight about it? Just decide on nothing at the first step and let the steward and foreman carry it on together to the others. They agree it is not right, but let the union sweat out each case in the higher levels of the procedure. This attitude is unfortunate, yet it is a natural reaction to be expected from unhealthy restrictions on the management function.

MANAGEMENT'S UNHAPPY POSITION

Management is in the middle, between the stockholders, and the workers. Management must produce results for both. Unions are pressing for the highest possible returns to the workers—all that industry will stand. What is left over goes to the stockholders, and management is expected to solve the problem and retain enough for the stockholders to keep them in the game.

There is a limit to what the worker can get which is determined by the general efficiency of the employees and its management therefore management should not hesitate to state bluntly that industry must get more work output per employee to improve the general standards of living, and that the burden of obtaining operational improvement falls squarely on the shoulders of management and the engineer.

We all favor higher wages, better standards of living, and more of everything for everyone, but we also know that higher wages and a shorter work week must go hand in hand with faster and better ways to produce these things. The trend today is to do less work, individually and collectively, and it is with the greatest difficulty that normal tasks which have been in existence for years are maintained.

A JOB FOR THE ENGINEER

The effect of this "less work" psychology is a serious resistance factor in the field of operating management. Obviously, existing fair tasks should be held before the industry may consider improved machinery. It would therefore seem that the engineer and operating management must develop techniques, procedures, and formulas to enable the industry to utilize the combination of the workers and the machine at its highest efficiency, and prove that the task requirements are fair and reasonable.

About a year ago there was formed a small informal group of operating millmen who had made a start in this field. Unfortunately, too few organizations are contributing. However, some progress has been made, and the data collected indicate a wide difference of viewpoint and formula in determining task and work loads in the various mills.

One member of this group has made an intensive study of the weaver's job, which indicates clearly the necessity for development of certain standards to guide the industry in general so they can set and maintain reasonable work loads. In this industry the early jobs just grew and were developed mostly by the "let's-go-and-try" method. Some turned out well, others poorly, and became fixed by long custom. Very few, if any, are overloaded today as the tendency in the past five years has been entirely in the other direction. The trend of union influence is naturally to standardize tasks at the lowest levels, therefore, operating management is forced into a more scientific approach to the matter in order to obtain and hold task requirements.

Various methods of time study have been introduced in recent years in some mills. There is considerable difference in the methods and allowance factors used. Some of the resulting incentive systems are highly complicated, others compromise with the situation, the result being that the industry's practices are open to criticism. In dispute and arbitration cases, the history of conflicting opinions is brought out and is detrimental to the setting of a fair task.

It is amazing the number of allowance factors that can be inserted into a weaver's work-load calculation, pyramided and thrust into the problem with little factual evidence—mostly opinion—and expressed in percentage of known measured elements. Such factors as personal, dressing time, fatigue, variation, process, and machine interference appear in the formulas, each with an individual percentage.

One case resulted in less than 30 minutes actual work in 1 hour. Some formulas call for a fatigue factor of 20 per cent, and then immediately eliminate the fatigue by a point system of payment and gain 10 per cent more worktime additionally. The careless use of the word "fatigue" is regrettable, and the misuse of various kinds of allowance factors must be studied seriously.

There is a sane reasonable answer to the problem if the industry engineers and operating managements will study and work on it. It is to be expected that the unions will use everything in the book to secure their position and improve earnings for the labor they represent, and it is management's job to know how and to see that the job is designed right and the compensation adequate.

It is a long tough road ahead, a continuous series of little battles between management and organized labor. Neither is perfect, and both have a lot to learn about getting along together.

It is extremely difficult to define and evaluate labor factors. When industry could arbitrarily set the job and the price with little fear of nonacceptance, there existed no basis for consideration of a labor factor in the calculations. It is only recently that we have been forced to recognize the endless differences of opinion that exist between management and labor, and try in different ways to resolve these differences.

UNION-MANAGEMENT CONTRACT STARTING POINT FOR BETTER RELATIONS

Whether the results are good, bad, or indifferent, we have to value them and add them in the total score to find out where we are going. The written union-management contract is the starting place that says you not only have a labor factor, but you also have got to measure it. Work-load, wage, and incentive clauses are common in all contracts today, and they give definite values. The next step in the further definition of factors is the methods and systems used in measuring work-input values and translating them into dollar earnings.

There has been very little consolidation of ideas or opinions on these matters in the industry, and it is obvious that this field should be explored. It is evident that some dislocation in rate scales is unavoidable if we are to secure a reasonably balanced work-input value to earnings.

This whole subject is involved so much with human reactions and political pressure angles that it is confusing and discouraging from an engineering viewpoint. How the engineer can adjust himself to meet the situation is not known. Management cannot avoid it. The Wagner Act says he must recognize and work out labor factors, some of which will be highly technical and will require engineering formulas.

Can the engineer's influence help modify certain political aspects in the picture and develop a better scientific understanding between all concerned, leading to a more workable set of factors than we have today? The answer should be in the affirmative—perhaps five years hence we will know.

A NATIONAL SPOKESMAN *for* ENGINEERS

By A. B. STICKNEY[1]

THERE are upward of 200,000 engineers in this country sufficiently interested in engineering as a profession to have joined a society, but not over 10 per cent of them belong to any one society. There is a widely felt need of over-all organization of the societies to act as spokesman for all engineers on matters of common concern. On a local basis, over 100,000 engineers in thirty-five metropolitan areas have organized themselves into local councils and are doing an effective job within their sphere of activity. In the last few years much has been said and written about a similar organization on a national scale. Everybody wants it—everybody is talking about it—it's in the air—it's coming—it's inevitable.

While it is no longer necessary to talk about why or whether there should be such an organization, there is no such unanimity about what it should be like. This paper outlines a proposed method of organization by answering four questions—who, how, what, and who will pay for it.

WHO IS ELIGIBLE?

First: Who? Itshould be built on the foundation that the American Standards Association has so effectively employed, that anyone having a legitimate interest has an inherent right to participate. There are five types of organization which have that legitimate interest.

They are as follows:

1 The so-called Founder Societies: Civil, Electrical, Mechanical, Mining and Metallurgical, and, included in recent years, Chemical Engineers. These societies have large memberships, and each embraces a whole field of engineering. Together they have perhaps 40 per cent of the engineers of the country on their rolls.

2 The specialized National Societies: The Agricultural, Automotive, Heating and Ventilating, Illuminating, Radio, Refrigerating, Tool, and a host of other engineers, each having its own society. While some of the members of these societies are also members of Founder Societies, there is a general disinclination to belong to more than one society, and a great many of them have dropped their Founder Society memberships because only an occasional paper or article has been of significance to them. On the other hand, in their specialized society a large part of the papers and other activities are of interest, and the closer contacts in the smaller groups are more stimulating. Beyond that, these societies generally have an associate grade of membership for the men who would not be eligible under the stricter rules of the Founder Societies, but who nonetheless practice engineering. These men must be included in any organization undertaking to speak for engineers as a whole. Collectively, these specialized societies have a larger membership than the Founder Societies.

3 Local specialized groups, similar to the specialized national societies but not organized on a national scale. There are a number of such organizations in the various local councils, and they undoubtedly exist in considerable numbers in all the larger metropolitan areas.

4 The local councils, which are composed of the local sections of National Societies and of local groups, so that membership is by virtue of membership in some other organization. A survey of the thirty-five then in existence was published by the Cincinnati Council in April, 1945. This survey, by Frank Sanford, past-president of the Cincinnati Council, has been widely publicized and is available on request, so that no elaboration is required here.

5 The local Engineering Societies or Engineers' Clubs, which have individual membership but which cut across the field and have members with all varieties of specialties. Probably all cities of over 100,000, and a great many smaller cities, have them. In a great many cities they are the only local organizations of engineers and provide the only direct contact many engineers have with others of their profession outside of business hours.

Trade associations or organizations having predominantly company memberships should definitely not be included, since the object is to represent the interests of engineers as individuals. But the line must be carefully drawn here. Such societies as the American Society for Testing Materials, with a combination of company and individual membership, should certainly not be excluded, at least in so far as its individual memberships are concerned.

Whether technologists in other fields than engineering should be included is a moot point. Chemists, physicists, biologists, food technologists, and the like are in several of the local councils. Probably they would not want to be included in a national engineering organization, but that is something for them to decide for themselves.

ORGANIZATION SETUP

Second: How? A governing body for a national organization would be formed by having each member body select one representative for a period of three years, with the larger organizations having more than one representative, say, on a basis of major fractions of 5000. Thus a society or council with over 7500 members would have a second representative, one with over 12,500 a third, one with over 17,500 a fourth, and so on. Confining these representatives to men who have held general elective office, such as past-presidents, past-chairmen, past vice-presidents, etc., would assure experienced responsible talent. Terms would be staggered so that one third would be elected each year. These men, and there might be a couple of hundred of them, would form the National Council. It would elect its own officers and the members of standing committees. The council would meet twice a year, and between times an executive committee, composed of the officers and the chairmen of all standing committees, would give effect to the decisions of the council. There would, of course, be a paid secretary and staff.

[1] Past-President and Chairman, Committee on Relations With Other Organizations, American Society of Refrigerating Engineers.

In addition to the usual committees necessary to the conduct of the business of the organization—Executive, Finance, Constitution and By-laws, Nominating, Membership, etc.—there would be a standing committee in charge of each activity the council undertook. Additional activities could be undertaken, and additional standing committees formed to supervise them, by, say, two-thirds vote of the entire council membership at two successive meetings, which would mean that any controversial points could be discussed by the governing bodies of the member organizations, and their representatives instructed, before a final vote was taken. However, the president, with the approval of the executive committee, could appoint special committees having a limited term and advisory or temporary executive powers.

FUNCTIONS OF ORGANIZATION

Third, and most important: What? This is the point where most of the disagreement occurs. There are many things the National Council might concern itself with, and some of them will be enumerated shortly. But what do the majority of engineers—the men the council will be spokesman for—want? Nobody knows, and nobody can know. The issues have never been laid before them; there is no mechanism for doing it. And right there is the answer to the question. Create the mechanism, lay the issues before them, and find out what they want! That's all that is necessary to start with, and it's a big job.

When the wants are known, the mechanism will be at hand to do something about them, with the safeguard to prevent going off the deep end that there must be a two-thirds vote at two successive council meetings, six months apart. After a few years there will be a variety of activities, but no one can predict today just what they will be. There are various co-operative activities going on today; to mention just one, the Engineers' Council for Professional Development; and if it is deemed desirable, these activities can be blanketed in as standing committees without any break in the continuity of their work.

What is the mechanism for finding out what is wanted? Start a magazine which will go to each of the individual members of each of the member organizations, by virtue of that membership, in addition to the publications of his own organization. Discuss the issues, present both sides, and let the membership of the various societies tell their representatives what they want.

A NEW CONCEPTION OF ENGINEERING JOURNALISM

The magazine would be divided into four main parts. The first part would contain policy articles; the social and economic status of engineers, licensing, collective bargaining, engineering education, pending legislation, standardization, sponsorship of research, patent policy, economic theory, national and international affairs, and similar subjects. Perhaps only 10 per cent will read the articles on any given subject, but 10 per cent of all engineers is in itself a large audience, and the rest will be proud to have the articles available, even if they don't read them. A magazine with the circulation we are talking about, going to all engineers, will be unique. There is nothing like it today, and it could command talent that none of the individual societies can touch. It will make it possible for the first time to lay before the entire profession the best thinking on both sides of issues of concern to engineers.

The second part of the magazine would contain informative articles on engineering matters of general interest. It would be written from the standpoint of telling engineers what is going on in the engineering world outside of their own fields of specialization. Such things as regional planning; development, utilization, and conservation of natural resources; flood control, city planning, superhighway-system integration, new railway equipment, developments in radio, automotive engineering, frozen foods, engineering materials and methods of their utilization, and the like; also technical matters which capture the public imagination from time to time and which the engineer feels he should know more about, such as nuclear physics and radar last year, would be discussed by authorities, but in a style which assumes only the basic engineering knowledge and viewpoint we all have and popularizes the subject from there on. This type of article would have a tremendous popular appeal and a broadening influence on engineers' viewpoints and fields of knowledge which might well prove the most valuable thing to come out of the entire program.

The third part of the magazine would be the news of the organization and of the member organizations, and of engineers individually. It would include a series of writeups of the member societies and councils, cross-sectional studies of how various societies solve organizational problems common to all societies, news of elections, meetings, activities of general interest, etc. News of individual engineers would be primarily from the standpoint of activities of interest to all engineers, or of activities outside the technical field, such as in civic affairs. A very important part of this section would be a forum in which the individual was encouraged to express himself on the issues being discussed or bring up new issues for discussion. Editors say this is a hard department to run—if so, its success would be a measure of the editor.

The fourth part of the magazine would be a combined index of the technical parts of the publications of all member societies, and perhaps of commercial technical journals as well, with the articles classified as to type (new contribution, survey, polemic, etc.) and a brief description, where the content is not evident from the title, so that the individual engineer could find out about articles of interest to him which appear in journals he does not normally see. Means would have to be provided for him to see the articles after he found out about them. This section would also carry book reviews and notices of publications of general interest, such as indexes of standards and the like.

FINANCING THE NATIONAL COUNCIL

Finally, Who is going to pay for it? Let each member group pay a $1 subscription to the magazine for each individual member. Where a man is a member of more than one group, split the dollar. Where membership in one group is by virtue of membership in another group which is already in the National Council, there would be no charge. Beyond that, the advertisers will pay for it. The magazine will be an advertising medium with a circulation which, from both the quantitative and qualitative standpoints, will be very attractive. After it is established, the magazine should not only pay its own way but should yield a profit which will support other activities of the council as they are authorized.

In conclusion, the Council of the American Society of Refrigerating Engineers has authorized the author to sit on an organizing committee to formulate a specific proposal and invite attendance at a general organization meeting to give effect to such a scheme, and it has made an appropriation to help defray the expenses of such a committee. A number of other groups have been invited to do likewise, and it is quite possible that such a committee will be functioning within the next few months. The thought is to keep it small enough to function efficiently and yet diverse enough so that its proposals will be generally acceptable and will not represent domination by any group.

PLANNING *for* EMPLOYMENT *of the* PHYSICALLY EXCEPTIONAL

By JOHN V. GRIMALDI

RESEARCH ENGINEER, NATIONAL CONSERVATION BUREAU[1]

IMPAIRED workers are no employment problem. It is true their physical assets may qualify them for only certain jobs, but everyone, impaired or not, is restricted to specific types of work at which he will be most successful. It is generally recognized now that a worker's efficiency is in part dependent upon whether his capabilities are equal to the requirements of a job—a matching operation that progressive personnel procedures attempt to achieve. It is on that phase of personnel direction that the program for employing the physically exceptional is founded. Such a program is merely a common-sense effort to properly place the disabled worker at a correct job. When this is accomplished, the worker can no longer be considered handicapped with respect to his work and is the productive equal of the so-called normal worker.

IMPAIRMENTS MUST BE VIEWED OBJECTIVELY

However, before one can recognize fully the employment equality between the impaired and normal worker, he must cleanse his thinking of any misconception concerning the impaired. He must be able to look at a noticeably impaired worker objectively and remember that a twisted, deformed, or lame body may be equipped, for example, with a fine mind or be capable of extreme dactyl dexterity. An impaired person may have any grouping of a number of outstanding abilities.

It is generally our unfamiliarity with severe impairments that corrupts our thinking, so that we evaluate the impaired solely in terms of the deficiencies we see. It would be more appropriate if we regarded such workers not as physically disabled, but as physically exceptional, so that the connotation of physical limitation is avoided. For as we now know when the physically exceptional person is properly placed he will be definitely a desirable employee. This has been demonstrated by many comparative studies of the safety, productivity, and reliability of normal and physically exceptional workers.

One of the most recent of these investigations was an exhaustive two-year research recently completed at the Center for Safety Education, New York University by Dr. Tobias Wagner. His findings showed, in part: "When properly placed, so that the disability does not affect the efficiency performance of a particular industrial job, the disabled workers generally are more efficient than normal industrial workers." The desirability of disabled employees is exemplified further by the results of such other studies as those made individually by the U. S. Office of Education, the Western Electric Company, the U. S. Civil Service Commission, and the American Museum of Safety in co-operation with the Center for Safety Education.

LOW ABSENTEE RATE AND HIGH SAFETY RECORD OF DISABLED WORKERS

A summation of the results of these studies demonstrates that, without exception, the disabled have been shown to be as productive as the able-bodied and in certain individual instances are superior. Also, they were found to have better labor-turnover records. Although one of the investigators reported that the average accident-frequency and sick-absentee rates were slightly higher among the physically impaired he studied, the other studies found that the physically impaired, in general, were superior in safety experience and absentee rate. The Wagner study showed that properly placed disabled workers had a better safety record than even the properly placed normal.

The demonstration of the relatively better safety experience of the physically exceptional compared to the normal, answers the question often asked, "Will the hiring of so-called disabled workers necessarily increase workmen's compensation insurance costs?" Of course it won't. Such costs will not increase if accidents do not happen, and the physically exceptional have been shown to be relatively as safe, or safer, than the average worker. But to remove all such doubts from the minds of employers, the Association of Casualty and Surety Executives has published the insurance-companies' official "Declaration of Attitude," specifically to encourage the hiring of such workers. The publication points out that the formulas for determining the initial rate for workmen's compensation insurance does not consider the employee's defects. Therefore no higher rate is charged because of employing physically impaired workers. It is true that the cost of insurance is reflected in the accident experience, good or bad. But the accident experience of disabled workers, in general, is definitely good, particularly when they are properly placed. This is possible, however, only when the employer has adopted a well-rounded procedure that will enable him to place an impaired person in a job where the work demands are equal to the individual's physical capabilities. When this is done, the disabled employee often surpasses his able-bodied neighbor.

ESSENTIALS OF A REHABILITATION PROCEDURE

Here, one might ask, "What are the essentials of a well-rounded rehabilitation procedure?" For a time we could not give a definite answer with any degree of assurance. Now, from the findings of the Arthur Williams Memorial research study, done jointly by the American Museum of Safety and the Center for Safety Education, we think we know. This research was made by surveying a group of more than 20 exemplary industrial rehabilitation programs, in selected parts of the country, picked by a jury of rehabilitation specialists. Seventeen programs were visited personally and studied "on the spot." The others, because of travel limitations, were contacted by mail. The industries chosen were both large and small and representative of many types of industrial operations. The total personnel of these companies was over 500,000. More than 30,000

[1] Division of Association of Casualty and Surety Executives, New York, N. Y.

Contributed by the Management Division and the Committee on Safety and presented at the Annual Meeting, New York, N. Y., Nov. 26–29, 1945, of The American Society of Mechanical Engineers.

of this total were handicapped. It is apparent therefore that the study covered a broad range of types of industries and numbers of industrial workers.

The principal objective of the study was to determine criteria for the evaluation of a well-rounded rehabilitation procedure for the proper placement of physically impaired workers.

These criteria were found to be as follows:

1 Is there a definite company policy regarding rehabilitation with provision for instructing the supervisory staff in the principles and practices of rehabilitation?

2 Are the job demands analyzed specifically for the hiring of the disabled?

3 Is a "standardized" interview used for determining the applicant's interests, background, and attitude?

4 Are his physical capabilities determined by medical examination?

5 Is he placed selectively by matching his physical capabilities with the job demands, as well as consideration for his interests and background?

6 Is there job training?

7 Is placement followed by periodic review?

When stated affirmatively, they may be considered to constitute the seven steps for the full program.

The objective of the seven steps comprising the complete selective placement program, is to insure the placing of a physically exceptional worker at a job that will match his physical capabilities.

FITTING THE IMPAIRED WORKER TO THE JOB

To facilitate the matching of a job's requirements with the disabled worker's physical capacities, we recommend the use of a guide developed to collect this information and so arranged that it can be employed simply, when matching the job demands with a worker's physical capabilities. To accomplish this we have prepared two forms. One specifically is designed for the recording of job requirements; the other assists the medical examiner in determining an applicant's physical capacities. Both are arranged so that when correctly completed, they will quickly indicate which jobs can be occupied successfully by any disabled applicant.

The method used is a kind of slide-rule device. For example, Form 1, the "Job-Analysis Form," is divided horizontally across the top into divisions descriptive of a company's job demands. Each division is numbered. The jobs to be analyzed are listed vertically down the left side of the form. This permits the recording of all of the demands which are part of each of the jobs listed. The recording is made by placing a check (√) mark in the appropriate box. Form 2, the "Physical-Capabilities Analysis Form," is used by the examining physician. Its horizontal divisions are described and numbered to correspond with those of the Job-Analysis Form. The physician is then able to examine an applicant specifically for the work demands of the jobs apt to be assigned. The findings are recorded on form 2, in the same manner as the job-analysis results were on form 1. It is then a simple matter to superimpose form 2 on form 1, aligning the matching columns, and by sliding form 2 vertically over form 1, determine whether a job's demands are in accord with an applicant's physical capacities.

Any job on form 1, having a check mark representing a work requirement that matches a check mark in the same column on form 2, may place demands on the worker that are beyond his physical capacity and therefore is not suitable. If it is eventually necessary to place him in such a job, the placement should be done only with the joint advice of the personnel man, physician, and safety engineer.

The successful placement of the physically impaired depends primarily on good personnel or management planning. If the job is well done, there should be a minimum of work for the engineer to do. The objective of the selective placement program is to fit the man to the job, not the job to the man. Therefore engineering revision of a job as a fundamental means for placing a physically exceptional worker is frowned on and should be considered only as a last resort.

BASIS FOR A SELECTIVE-PLACEMENT PROGRAM

From the results of our work in the field of selective-placement programming, we can recommend the following to those employers as yet without a definite program for the employment of the physically exceptional:

1 When they do adopt such a procedure, they base it on a program or composite of programs that have been found to operate successfully.

2 Employers should plan meetings with their supervisors and provide instruction, in order to make certain any misunderstanding and prejudice toward the disabled are overcome.

3 Whenever possible, look for medical, personnel, and safety assistance concerning the correct placement of the physically handicapped. If the employer has no safety officer, he should by all means call on his insurance safety engineer. Too often a safety engineer is not included in placement conferences.

4 Do not think of rehabilitation solely in terms of the returning veteran. The average ex-service man will return an even more desirable employee than when the armed services beckoned. He has been trained, knows the value of loyalty and is in the most employable age group. It is only a relatively few who will be marked by combat, and only these men will need the special procedures designed for employing the physically impaired.

If we permit ourselves to think of the selective-placement program as a need concerning only the returning veteran, it will be unfair to the greater number of veterans, and unfortunate for the future employment of the physically handicapped. Employing the disabled has long been a socio-economic problem. Its solution now seems imminent, but the good work that has been done may be destroyed if we feel that our efforts have ended when we have provided for the disabled service man.

SOUND PERSONNEL PROCEDURES HELPFUL TO ALL WORKERS

In our study we found that the companies having sound personnel procedures tend to have good selective-placement programs. This should be of tremendous significance to employers. It means that essentially the success of disabled workers has been brought about largely by sound, progressive personnel procedures. Since these procedures have been shown to be successful for the disabled, could we not expect similar results when their fundamentals are applied to the employment of all workers, disabled or not?

The so-called rehabilitation problem and the resultant studies for its answers have a deeper significance than we might casually observe. The humanitarian and economic motives that touched off the demand for research investigations have done more than just aid the previously almost forgotten handicapped man. They have brought results that will show the way to better personnel procedures for all working men. The development of new personnel methods and the worth of some now used that have been proved through these studies, should be applicable toward improving the success, morale, and safety of all workers.

BRIEFING THE RECORD

Abstracts and Comments Based on Current Periodicals and Events

MATERIAL for these pages is assembled from numerous sources and aims to cover a broad range of subject matter. While few quotation marks are used, passages that are directly quoted are obvious from the context and credit to original sources is given.

Atomic-Energy Uses

BECAUSE of the wide interest displayed concerning the future peacetime uses of atomic energy, the following symposium revealing some of the thoughts of scientists well-versed in the subject of atoms is presented here:

J. R. Dunning

An address in which he revealed the possibility of harnessing atomic energy for commercial purposes, was delivered by Dr. J. R. Dunning, director of Columbia University's division of war research, Jan. 23, 1946, before 1800 engineers at the American Institute of Electrical Engineers' Winter Convention, held in New York, N. Y.

Dr. Dunning told the audience that one pound of U-235 will produce as much power as $52,000 worth of aviation gasoline. The cost of one pound of U-235, however, is still a military secret, but outside observers estimated that production costs are from $10,000 to $50,000 per pound, depending on the particular production method utilized. Assuming a peacetime production cost of $20,000 per pound, atomic power may someday be able to undercut coal as a source of energy in large power plants. If certain engineering problems could be solved, atomic power might well be able to compete commercially today with premium fuels such as aviation gasoline.

Citing an actual application of atomic energy, Dr. Dunning stated that it could be used effectively in extremely large power plants, such as those powering battleships. Shielding between the atomic boiler and the workmen must be six to eight feet thick in order to intercept the radioactive waves given off when the atoms split. The size and weight of this shielding rules out the use of atomic power in automobiles, homes, and airplanes.

He said that the atomic boiler must be built around at least two pounds of U-235—minimum cost $40,000—to work. Atomic power is produced by a chain reaction, in which neutrons fired from one exploding atom touch off explosions in near-by atoms. In masses of U-235 smaller than two pounds, many of the neutrons fly off into space and the chain reaction gradually dies out instead of producing a steady flow of energy.

Reduction in the cost of producing atomic fuels may come by burning U-235 in a low-level chain reaction to transform U-238, a form of uranium more than 100 times more plentiful, into another atomic fuel, plutonium. This technique and others developed by atomic-bomb research have already made the extensive plants at Oak Ridge, Tenn., technically "obsolete."

In comparing the effectiveness of atom-splitting with other means of generating power, Dr. Dunning pointed out that burning one molecule of coal produces two electron volts, whereas splitting a single uranium atom produces from 150,000,000 to 200,000,000 electron volts.

The first commercial uses of atomic energy will probably be along conventional lines to drive generators. Later it may be possible to convert atomic energy directly into electrical energy without turbines. Its real future is tied to development of metals and reflectors that can utilize the relatively high temperature of which atomic energy is capable.

Philip Morrison

In a paper entitled, "The Fundamental Economics of Nuclear Power," prepared by Philip Morrison for The Association of Los Alamos Scientists, he said the following concerning the use and cost of atomic energy as a fuel:

It must be realized that atomic energy so far as we now can see will replace the coal in the power plant, but it will not eliminate or even simplify the turbines, the great generators, the switchgear of the plant. Certainly it will not shorten the miles of power line which carry the power to the home, or simplify the billing system which mails a million bills each month. The cost of fuel—and atomic-energy sources do not supply mechanical work or electric power, but merely serve as fuel—is but a fraction of the cost of consumer's power. Even for large industrial power users, the fuel cost is at most 20 per cent of the cost of power.

The substitution of atomic-energy sources for ordinary fuels is, then, not at all decisive economically even if atomic "fuels" become much cheaper than they are today. Very much will depend on the cost of the installation and up-keep of the atomic power plant, which will, as far as we now know, still contain the turbogenerator of our big plants today. Only instead of the great piles of coal, the stoking machines, the roaring fires, and the tall smokestacks there will be a quiet atomic-energy source. Only if for special reasons the transportation of coal is impossible or prohibitively expensive will this change be made economically and on a reasonably large scale. Perhaps a hotel for winter sports on the South Polar ice cap or in Arctic Siberia could afford an atomic power and steam plant.

B. W. Sargent

In a paper "Atomic Power," presented before the Montreal Branch of The Engineering Institute of Canada on Nov. 8, 1945, and appearing in the December, 1945, issue of *The Engineering Journal*, B. W. Sargent, head of the Nuclear Physics Division at the Montreal Laboratory of the National Research Council, said, when speaking about the immediate future of nuclear (atomic) energy, that certain limitations must be kept in mind. Chain-reacting piles are large and must be surrounded by heavy concrete shields. Once a unit has been operated at appreciable power it is impossible to go inside the shield, even when the plant is shut down, to make adjustments or effect repairs, owing to the hazard of the gamma radiation. (The neutrons that maintain the chain reaction and the

gamma rays from the accumulated fission products are damaging to biological tissue.)

Nuclear power units of the pile type will probably be used only in special cases. A large stationary power installation might be used for heat and motive power in the Arctic or Antarctic regions far removed from water power and where difficulty of transporting other fuels such as coal or oil outweigh the disadvantages and difficulties of operating and maintaining a nuclear power plant. The use of nuclear power in the near future for propulsion except perhaps in battleships or large rockets is a remote possibility.

He said further that vast amounts of radioactive materials—the fission fragments—accumulate in the uranium in a plant such as that at Chalk River. Almost any material inserted inside the concrete shield will become intensely radioactive. Out of this comes the prospect of new and far-reaching applications of these radioactive materials in industry, biology, and medicine.

In industry these materials may be used to supplement radium and x rays for the radiographic inspection of castings, welds, and forgings.

In biochemistry and pharmacology these materials will permit the fullest applications of the tracer method in studying the movement of specific atoms through an organism.

In the treatment of cancer these new radioactive materials will greatly supplement radium and x rays, and make possible cheap but effective treatment at many clinics.

Thomson King

The following remarks concerning the possible commercial uses of atomic energy were made by Thomson King, commercial engineer, Consolidated Gas Electric Light and Power Company of Baltimore, in an address which he delivered recently before the Maryland Academy of Sciences:

The possibilities of the use of atomic energy for commercial purposes has captured the imagination of the world. Many people seem to believe that the use of coal and oil will be curtailed or abandoned in favor of atomic energy. While it is always dangerous to predict that anything is impossible, I will say that I believe it highly improbable.

Millikan, one of the foremost authorities on atomic physics in the world, has stated that he does not believe there will be widespread applications of atomic energy to commercial purposes now or in the future. Einstein has expressed the same opinion. Another high authority has stated that the amounts of energy that went into the production of the atomic bombs used in Japan was about 100 times the energy released by their explosion. Even if we could improve this ratio so that the amount of energy available for useful work from a given amount of active material could be made equal to the energy expended in producing it, the cost of such production would be much greater than the cost of an equivalent amount of energy produced by coal or oil.

It also seems that no chain reaction can be established except in a relatively large mass of active material and that this critical mass is so great that it could only be used for generation of power on a large scale. Compton thinks any plant to use atomic power must weigh at least 50 tons, so you will hardly be running your autos and planes on it.

In considering commercial possibilities, we must also remember the scarcity of the material and that it is probable that the available uranium will be held and conserved by governments for military purposes.

I think we may sum up the situation by saying that the men who are in the best position to know see no prospect for the immediate use of atomic energy for power or heat production. Some of them think that this may be accomplished in the future, but many discoveries must be made and much research must be carried out before even this is anything more than a more or less remote possibility.

It is possible that there will be very many by-products made available. I should expect that radium would be one of these, also that many other radioactive elements that are created would have a wide application in medicine and possibly in industry. We are sure, however, that the bounds of human knowledge have been enormously extended; that the use of atomic energy will have a very great effect on military plans and on world politics.

The entire text of Mr. King's address appears in the January, 1946, issue of *The Baltimore Engineer*.

School Laboratories

Electro-Acoustic Laboratory

THE Electro-Acoustic Laboratory, the first laboratory at Harvard University to engage in National Defense research, has closed its doors after five years of highly secretive and significant war work for the Army, Navy, and Marine Corps.

Its first assignment, for the Army Air Forces, was to investigate means for quieting the noises inside long-range bombing planes so that the personnel could do their job with less fatigue; and second, to investigate means for improving communications between crews of aircraft flying at altitudes above 20,000 ft, for the Navy Bureau of Aeronautics.

This meant examining the reasons for communications fail-

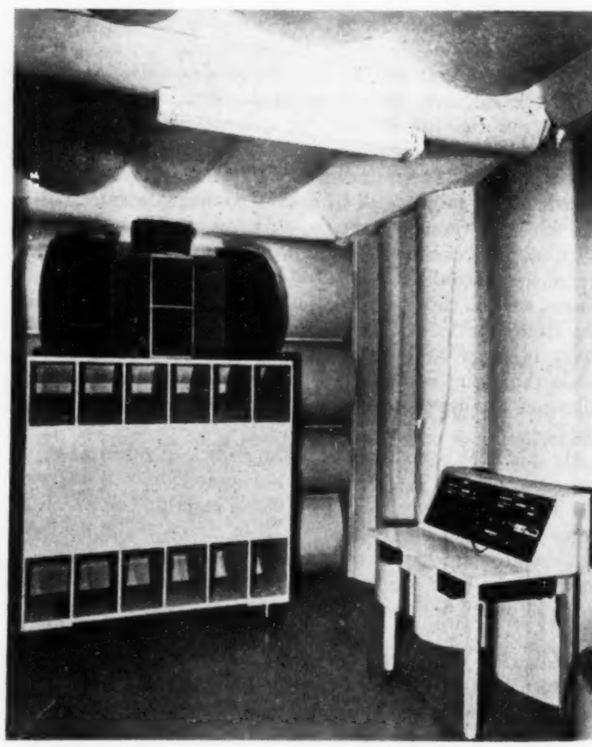


FIG. 1 DIFFUSE SOUND ROOM IN WHICH NOISES HEARD IN A PLANE DURING FLIGHT ARE REALISTICALLY REPRODUCED

(The room permits testing microphones, amplifiers, and headsets in an intense and diffuse sound field.)

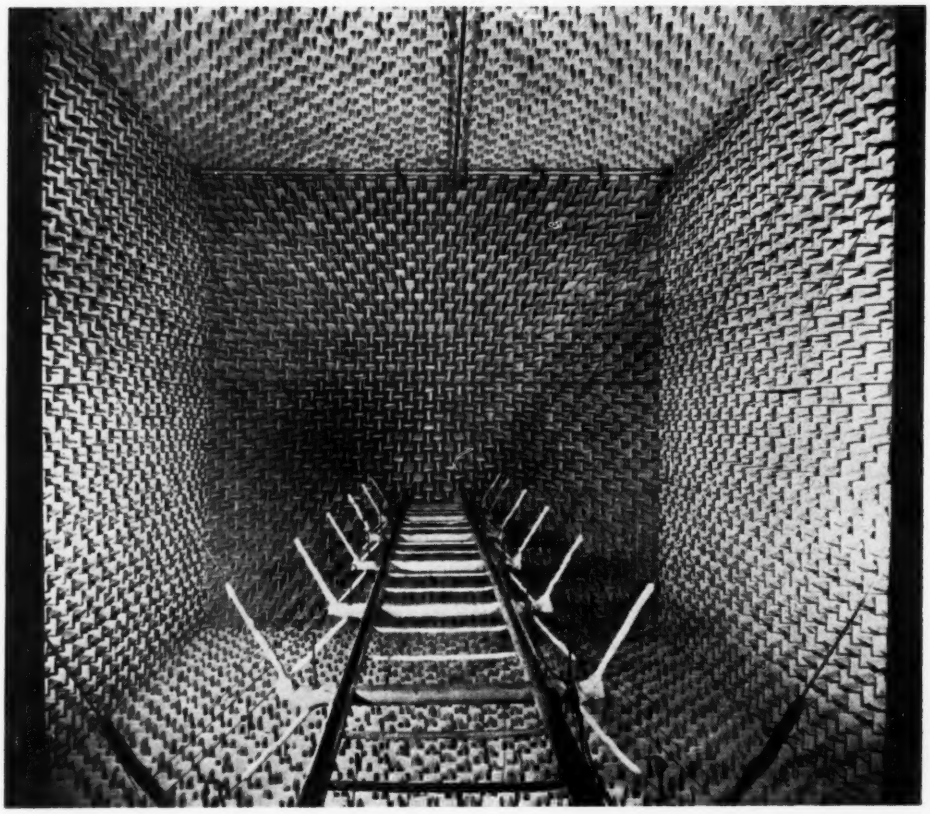


FIG. 2 INTERIOR OF ANECHOIC CHAMBER

(Lined with wedges of Fiberglas, the chamber presents the appearance of a room covered with thousands of stalagmites and stalactites. The chamber was built to permit testing of communications equipment under sound conditions existing in the atmosphere.)

ures, designing or specifying new kinds of equipment, and assisting companies in building and testing new microphones, headphones, and amplifiers which would be required.

For the first project it was necessary to find a material which would alleviate excess sound in airplane cabins. Out of exhaustive research and new discoveries grew a material sold under the trade name of Fiberglas AA. This material is made from thousands of glass fibers which are $^1/_{100}$ of the diameter of a human hair. These glass fibers are coated with a plastic binder which holds them together, forming a bronze-colored blanket that is $^1/_2$ in. thick and weighs $^1/_{20}$ lb per sq ft.

Installation in the airplane consisted of two $^1/_2$-in. blankets of the Fiberglas sewed on opposite sides of a sheet of asbestos paper and the combination mounted inside the plane about three inches away from the fuselage skins. The assembly was covered with decorative cloth. This method of reducing noise was highly successful, and the Boeing Super-Fortress, one of the quietest military planes flying, was the laboratory's most outstanding example of successful quieting.

To improve the operation of communications systems for the Navy, two aspects were involved: First, the determination of the way in which the human voice and the equipment varied as the atmospheric pressure was reduced to the very low values existing above 20,000 ft; and second, the recommendation of new equipment designs to be adopted and manufactured for use at high altitudes. The communication equipment was tested by the Psycho-Acoustic Laboratory at Harvard, using a procedure called "articulation testing." Articulation testing is conducted in the following manner: A person reads selected words over a communication system while it is operating under flight conditions and a group of listeners write down those words they understand. The percentage of words correctly recorded is called the articulation score. New devices for improving communications systems were built at the Electro-Acoustic Laboratory and sent over to the Psycho-Acoustic Laboratory for articulation tests.

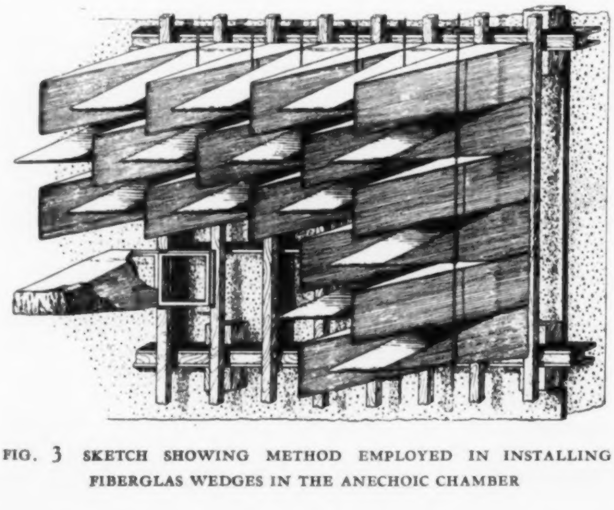


FIG. 3 SKETCH SHOWING METHOD EMPLOYED IN INSTALLING FIBERGLAS WEDGES IN THE ANECHOIC CHAMBER

One of the fundamental things that had to be known was how the human voice varied as a function of altitude. A year of hard work resulted in the development of a complex machine called an "audio spectrometer" which split up the sounds of speech into thirteen different bands—one band covering the very low tones, another band covering slightly higher tones, etc., until all the tones produced by the voice were included. Men wearing suitable oxygen masks and equipped with microphones and earphones were taken up to an altitude equivalent to 40,000 ft for two-hour stretches, where they read sentences, words, and vowel sounds over the microphones. The audio spectrometer measured how loud they were talking in each of the different tonal bands. Every week they were given complete physical examinations, including electrocardiograms and x rays of the lungs.

Several interesting things were learned. First, the human voice decreases in intensity at 35,000 ft to a value of about one tenth of its strength on the ground. No change in hearing was

found. As a result of these discoveries, special amplifiers were built whose amplification automatically increased as they were carried to higher and higher altitudes. It was also found that the tonal quality of the voice changed with altitude. At 35,000 ft the consonants seemed unusually distinct and there was a booming of the voice in the lower register. A lack of quality was added by the nasal passages. The talker experienced some difficulty—his nose felt stuffy and his throat cottony. There was an inability to speak more than two or three words without taking a breath. Also, the presence of the oxygen mask changed the tonal quality of the voice, amplifying the low notes. The microphones and the amplifier had to be built so that they amplified the higher notes more than the lower ones, thus removing the booming sound.

ANECHOIC CHAMBER

The laboratory's work demanded the construction of a special room called an anechoic (without echo) chamber. This room was built to simulate the atmospheric conditions existing at one to three thousand feet above the earth. The walls are almost perfectly absorbing, that is, less than $^1/_{1000}$ of the sound which strikes a wall is reflected. This same situation exists above the earth where there are no buildings, walls, or ground to reflect sound.

The chamber is completely windowless and is housed in a concrete building whose internal dimensions are 38 × 50 × 38 ft and whose side walls are one foot in thickness. There are no pillars or beams inside the room. The walls are lined with 20,000 wedge-shaped structures made from eight carloads of Fiberglas PF insulating board having a density of 2.5 lb per sq ft. These wedges were formed by sawing up the Fiberglas boards into the shape of wedges and putting muslin bags over the outside. Each of the wedges is about 45 in. long and is 8 in. square at the base. They are held out a distance of 10 in. from the concrete walls by a wooden framework. Behind the framework is an egg-crate assembly of fiberboard in cells 6 in. × 16 in. which prevents the sound waves from traveling backward and forward parallel to the walls behind the wedges.

The wedges, set snugly together, each turned at right angles to its neighbor, completely cover the walls, ceiling, and floor. The massive entrance doors are lined with them so that all surfaces present a uniform appearance when the doors are closed. To prevent sagging, each wedge is braced by a piece of heavy wire running under its center and fastened on each side to lengths of sash chain which hang from ceiling to floor between the wedges.

A four-foot track, held twelve feet above the concrete floor by cables, provides access to the chamber. Small cars carry apparatus into the chamber on this track, and their covered tops provide a catwalk into the chamber. Cars usually are removed before experiments are run to avoid sound reflection from them, and the experiments are manipulated from control rooms which have electrical and telephone connection with the air-conditioned chamber.

Cornell Aeronautical Laboratory

The combined gifts to Cornell University of Curtiss-Wright's $4,000,000 airplane division research laboratory in Buffalo, N. Y., and $675,000 in working capital from The Aviation Corporation, Bell Aircraft Corporation, Fairchild Engine and Airplane Corporation, Grumman Aircraft Engineering Corporation, Ranger Aircraft Corporation, and United Aircraft Corporation, creates one of the finest privately owned research units in the world.

According to Dr. C. C. Furnas, director of what is now known as the Cornell Aeronautical Laboratory, the laboratory's objectives are to do a "comprehensive job in all phases of industry's problems connected with aeronautics in order to maintain U. S. leadership in aviation, and to provide professional training for advanced students of aeronautical engineering."

The laboratory is considered by Cornell University officials to be a "meeting ground" where industry and education can get together for the training of future top-flight aeronautical engineers and, at the same time, contribute through research the greatest possible advance in the technique of airplane design, construction, and operation.

Students in the Graduate School of Aeronautical Engineering at Cornell will divide their time between the Ithaca, N. Y., campus and the laboratory in Buffalo. They will carry on individual or special research projects, or combine their work with others on research assignments toward the completion of a thesis.

Besides making a number of important contributions to aviation during 1942–1945, while under the direction of Curtiss-Wright, other fields in which the laboratory has conducted and continues to conduct research are: Supersonic speeds through the use of small wind tunnels; wood and plastics for lighter, stronger airplane parts; laminated rotor blades and a constant-speed rotor control for helicopters; automatic flight testing; experimental flight-test instruments; carburetor-duct de-icing; improvement of aircraft heaters; a number of tools or devices for industry, including a multi-arc welding process, automatic soldering gun, and a special cable cutter.

The laboratory's $2,500,000 wind tunnel which will be completed within a few months, incorporates the most modern design features for the study of high-velocity flight. Wind speeds of 740 miles per hour and working pressures ranging from $^1/_4$ to 4 atmospheres will be available.

At the present time the laboratory staff is engaged in research and development work on several projects for aircraft companies, embracing advanced work in aerodynamics, dynamics of structures, instrument development, utilization of new materials, and the design and development of new aircraft devices. Dr. Furnas anticipates that this research program will be augmented in the very near future by basic research work of Cornell graduate students.

Ohmite Laboratory

Illinois Institute of Technology's Ohmite Laboratory, established to provide a unique service to industry in the field of electrical measurements, will make its facilities available to sponsoring organizations beginning this month, it was announced by Dr. Jesse E. Hobson, director of the Institute's Armour Research Foundation.

The result of a $32,500 contribution by David T. Siegel, president of the Ohmite Manufacturing Company, this laboratory will provide precision measurement of electrical and magnetic quantities for the Chicago area, approaching in accuracy those of the Bureau of Standards in Washington.

Located in the Engineering Research Building at Technology Center, the laboratory is operated jointly by Illinois Tech's electrical-engineering department and the electrical-engineering division of the Institute's Armour Research Foundation. It will also be used for graduate study and in electrical standardizing work for the various departments of the Institute.

Although some equipment for the precision measurement work is not yet available, the laboratory is equipped for the following activities: calibration of standard cells, shunts, standard resistances, capacitors, inductors, direct and alternating-current ammeters, voltmeters, wattmeters, and watthour meters; conductivity measurements and insulation-resistance measurements; determination of the properties of magnetic

materials; measurements of power factor and dielectric constants of liquid dielectrics; oscillographic work; and radio and radio-frequency measurements including frequency checks and field-strength determinations up to 20 megacycles, determination of Q and antenna impedance.

The activities in the Ohmite Laboratory are expected to include high-voltage measurements up to 100,000 volts by the middle of 1946 and the scope of the audio- and radio-frequency work will also be increased.

Power companies, manufacturers of various kinds of electrical equipment, and colleges in the Chicago area will undoubtedly be among the organizations which will immediately benefit from the project.

Gas Turbines

A REPORT by the Turbine and Condensers Subcommittee of the Prime Movers Committee, Edison Electric Institute, publication No. L3 published 1945, reveals the following manufacturers' statements regarding gas turbines:

ALLIS-CHALMERS MANUFACTURING COMPANY, INC.

The useful possibilities of gas turbines will not be known until actual service experience becomes available on which predictions of the commercial future of this prime mover can be based. Experimental work is being performed on new materials which are expected to be suitable for considerably higher temperatures than now used. The adoption of the gas turbine as a prime mover depends to a considerable extent on the highest practicable temperature that can be employed and while at the present time it is not possible to disclose fully new developments associated with war products, it may be said that substantial progress is being made.

New materials developed for gas turbines will be available for steam-turbine work, and it is quite possible that they will permit an increase in existing maximum steam temperatures.

GENERAL ELECTRIC COMPANY

The gas turbine has had a great impetus given to it by the war-sponsored developments of the airplane-engine supercharger materials for this machine and the development of more efficient air compressors. As yet it appears that its fuel would have to be oil, although coal-burning gas turbines loom as a future possibility.

In its simpler forms and at reasonable temperatures, it appears to have over-all thermal efficiencies in the neighborhood of 18 to 20 per cent, in capacity from 1000 to 5000 hp. Higher efficiencies look possible, but at higher temperature or with the addition of heat-transfer surface that exceeds the surface required per horsepower in a boiler, air preheater, condenser, etc., of a modern steam station, which, of course, causes it to lose some of its attractiveness as a competitor to the steam power plant.

The big opportunities for the gas turbine at the present time would appear to be in the transportation field where its simplicity, low weight, and ability to operate independently of water supply will give it a unique advantage.

The gas turbine has been suggested as a low-cost, peak-load plant for automatic operation on the outskirts of a system where condensing water may be scarce. The bomb-proof reserve power plant publicized in the Swiss magazines several years ago represents an ideal application. In so far as peak-load requirements themselves are concerned, this country has generally had a sufficient capacity in obsolescent equipment to take care of such requirements without incurring the new investment cost which would be required to install the gas turbine. Such reserve capacity is, however, generally near the centers of load rather than on the outskirts, and there may be opportunities for some application of gas-turbine plants in this way.

One characteristic of possible application in the power-generation industry is pointed out by the early attempts in Europe to exploit the gas turbine which led to pressure combustion in a supercharged furnace. Eventualities of this sort are not out of the question.

WESTINGHOUSE ELECTRIC COMPANY

The past few years have seen intensive development of power generation using gas as the energy medium, this including exhaustive analysis of the cycle possibilities, machine design, and manufacture. Our practical work in this field has for reasons of security been of a strictly confidential nature. It is our belief that the use of combustion-gas-turbine plants in the central-station industry will, in general, follow its development for more favorable types of service, as, for instance, in the transportation field.

At the present top-operating steam temperature, the modern steam-power cycle has an advantage in efficiency which, however, it loses at approximately 1200 F. The gas-turbine plant is better adapted than the steam plant to utilize these higher temperatures. The simple gas-cycle plant is limited to unit sizes smaller than are required for central stations, though by closing the cycle and increasing the gas pressures this obstacle may be removed. For broad use in central stations the gas cycle must be developed to use solid fuel; and to retain the full advantage of compact equipment it must be internally fired. This presents a problem yet to be solved.

One other consideration of importance is the useful life of the turbine. Steam turbines are generally evaluated for twenty-year life, and are used for thirty years or more. To realize the potentially great advantage that extreme high temperatures offer in the gas cycle it may be necessary to modify this life expectancy downward to a material extent; this, however, may not be as serious as it at first appears, since but a relatively small part of the whole system is subjected to the maximum temperature.

For all practical purposes the gas turbine for primary power production is a problem for the postwar period.

200-In. Telescope

SCIENTISTS of the California Institute of Technology are back at work completing the world's largest telescope, the 200-in. giant installed atop Mt. Palomar in California. Progress on the instrument, which is expected to enable astronomers to peer one billion light years into space, was interrupted by the war.

Resumption of work on the telescope recalls many of the ticklish engineering problems involved in building the huge 500-ton mounting that will support the 200-inch mirror and optical system. Toughest of these, perhaps, was the job of fabricating and machining the 317,000-lb horseshoe bearing on which the telescope will ride on its tour of the skies.

The bearing, along with the rest of the mounting, was built at the Westinghouse Works in South Philadelphia, which was assigned the job because it was one of the few plants in the world with space and equipment large enough to handle it. But the task of machining the steel surface of the bearing to the specified tolerances required a boring mill larger than any heretofore used. So the bearing was shipped via three freight cars to the East Pittsburgh plant, where a boring mill—already one of the world's largest—was enlarged to a diameter of 44 ft. Then began the work of paring off the steel until

the bearing was within five one thousandths of an inch of a perfect circle.

Almost immediately engineers ran into trouble from sun rays streaming through shop windows. Every afternoon at four o'clock the bearing began to swell from the sun's heat, sometimes as much as thirteen thousandths of an inch. At night it contracted. After several partially successful efforts to solve the problem, engineers finally built a "sunbonnet" around the bearing that reduced temperature fluctuations by 50 per cent.

Then, because the bearing must support a million-pound load, engineers had to bend it literally out of shape so that it would be squeezed back into a perfect circle when the telescope rested on it. Some idea of the meager tolerances engineers had to work with can be gained from the fact that the telescope must be sighted with an angle of error so small that at three miles two lines drawn from a single point would be only an inch apart.

The bearing will run on oil pads with such frictionless smoothness that it could be turned by a motor having less than half a horsepower, this in spite of the fact that the telescope and its supporting structure have the proportions of a six-story building. If conventional roller bearings had been used the friction would have been 600 times greater—a measure of the infinite skill put into construction of the world's largest precision instrument.

Lock Nuts

NO completely satisfactory solution of the lock-nut problem has apparently been reached because it seems that scientific workers have failed to analyze the causes that make nuts come loose.

In the Dec. 7 and 14, 1945, issues of *Engineering*, Dr. H. S. Rowell gives an account of the investigation into which he was led when called upon in 1929 to solve the problem in general terms.

Vibration obviously makes nuts work loose; however, vibration sometimes tends to make nuts become tighter, but not so that it is noticeable by the ordinary engineer. The rotative forces at work in vibrating machines suffice to drive nuts off but they are not sufficient to produce a marked increase of tightness.

Some of the ill-founded beliefs concerning the shaking loose of nuts in practical experiences were: Nuts on the upper ends of bolts worked loose less often than nuts on the bottom ends of bolts. No concrete evidence is available to substantiate this theory. Another view widely held was that studs never worked loose. This is, however, untrue. Studs seldom work loose and if properly fitted, and in hard metals such as steel or cast iron, they almost never work loose. A third belief was that motorists and cyclists held the view that rotating bodies tend to turn on their threads—the direction of rotation. There is a basis of fact underlying this belief, and manufacturers of repute during several years fitted left-hand nuts on the left-hand or (in England) rear-side wheels. But on motorcar wheel studs today, the threads are universally right-hand threads and if put on properly and pulled up tight the nuts rarely if ever come loose. If oil or air, or both, are trapped in stud holes or box nuts, the stud or nut tends to become loose because it was never tight; it was never a metallic assembly because of the trapped cushion of air or oil. If an air groove is cut on the stud, the assembly can be made tight, metal to metal. With the German practice of leaving a space at the stud end and jamming the stud on the thread end, no groove is needed, and the threads bite almost to the seizing point.

When a nut is screwed on to a bolt: (1) The bolt is twisted by friction at the threads; (2) the bolt is stretched by the pull of the nut; and (3) the contact faces at the threads and at the nut and bolt-head faces are in a state of shear stress opposing the screwing up of the nut. If these conditions are considered in detail it is not easy to discern any reason why a nut should slack back.

All nuts do not work loose in vibrating systems, even if they are not provided with locking devices. However, if through vibration or cyclic variation of load the contact between bolt and nut is interrupted, rotation and slacking back can occur.

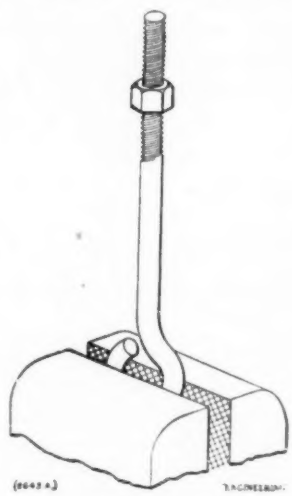


FIG. 4 HOOKBOLT AND NUT CLAMPED IN VISE

But the main cause in the lock-nut problem is much more interesting. A 1/2-in. hook bolt and nut was clamped in a vise as in Fig. 4, and the bolt gently tapped with a hammer to set it in vibration. Surprisingly the nut spun around on the bolt and ascended more than two turns. When the bolt was tapped at another point on the other side, the nut rotated in the reverse direction and descended between two and three turns. This hook bolt was then mounted in the vise in various positions from vertical to horizontal and with varying completeness of clamping at the hook. Similar results were obtained, leading to the conclusion that transverse vibration of the bolt causes the nut to rotate on it.

The motion of the end of the bolt, as observed through a lens, was seen to be an ellipse, the axes of which could be altered by varying the clamping conditions.

Further experiments with bars and washers and bolts and nuts proved beyond doubt that a gentle blow on the side of a bar or of a bolt sets the bar or bolt in vibration so that a washer or nut on the bar or bolt is caused to rotate. The direction of rotation is largely a matter of chance, depending on the direction, point of impact, and violence of the blow but the amount and speed of rotation seemed to depend very largely on the clearance between bolt and nut or bar and washer. An arrangement whereby a bar could be made to move at a measurable speed in a circular path but without rotation was devised. Into the inner race of a ball bearing, having an eccentric outer race, a bar was fitted tightly so that it moved solid with the inner race, and so was able to follow the circular orbit of the eccentric outer race without rotation. The setup is seen in Fig. 5, where the inner race is anchored against rotation by a flexible steel torque wire, notched and soldered into the end of the bar. The outer end of this bar was made 0.51 in. in diameter to take the washers, numbered 0 to 8, used in the observational studies. When the outer race was rotated, the bar moved in a circular path without rotation and the washer moved round the bar.

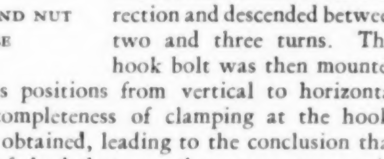


FIG. 5 ONE OF THE ARRANGEMENTS DEVISED TO CARRY OUT LOCK-NUT EXPERIMENTS

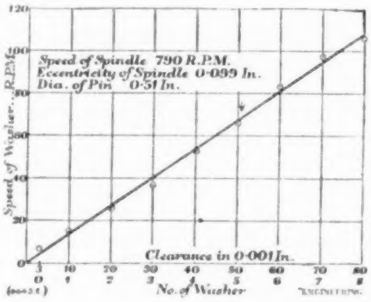


FIG. 6 GRAPH SHOWING RELATION BETWEEN SPEED OF WASHER AND CLEARANCE BETWEEN WASHER AND PIN ON WHICH IT IS TURNING

When the motion of the washer had become steady the number of rotations made by it were counted, and the results obtained are shown in Fig. 6 which brings out the remarkable linear relation between the speed of the washer and the clearance between the washer and pin on which it is turning.

The outstanding recommendation is that bolts and nuts should be a good fit. With V threads a good fit is easy, because of the conical surfaces, provided that the threads are of accurate pitch. If accurate threads are used there is no need for a nut locking device, but since accuracy is a matter of degree it may still be prudent in cases of severe vibration or serious risk to use a nut lock as a precaution. Fiber inserts are useful if the life and perishability of the fiber are kept in mind. Spring nuts insuring a close radial grip of the bolt thread give enhanced accuracy of radial fit. A conical seat for the nut, as on motorcar wheel studs, is very effective and reliable when such seats and nuts are practicable. Positive nut locks of the pin and wire and tab-washer kind are obviously effective, but their simplicity is ensnaring and too reassuring. For more permanent fastenings, as in structural steel work and on fine instruments, peening, riveting, and burring-over are well-tried and popular, but a neater kind of practice with less labor and more freedom from error in operation, is available in the use of cements and glues.

New Russian Coal Field

VORKUTA, reveals the January, 1946, *Science Bulletin* of the American Soviet Science Society, is now regarded as one of the biggest coal fields in the Soviet Union, containing 120,000,000,000 tons while the Donets Coal Basin, most highly developed in the country, contains only about 90,000,000,000 tons. Located well beyond the Arctic Circle, almost as far north as the sixty-eighth parallel, Vorkuta has robbed Bogoslov coal field in the Urals of its boast of being the northernmost coal field in the Soviet Union.

The new coalfield is situated in the basin of the Pechora River. On the east of the broad basin there are the almost inaccessible North Ural Mountains. To the north there is the Arctic Ocean. Everywhere in whichever direction one looks, there is endless swampy tundra.

Geological research under arctic conditions is always extremely difficult and dangerous. The Academy of Sciences expedition, sent to the region in 1912, was overtaken by a fierce snowstorm and half its members perished. (In winter temperatures often reach 55 or 60 C below zero.) Intensive geological research began in the Soviet period. In the 20's and 30's geologists proved that coal deposits in the frozen north were extensive. Chemical analysis and experimental exploitation showed that the coal of Vorkuta was of high calorific value, was easy to coke, and was suitable for extensive use in iron smelting. The workings of Vorkuta were opened in the early 30's, when there was already a big demand for its coal in view of the rapid economic development of the Far North.

Great difficulty, however, was encountered in delivering the coal to the consumer because the Ussa River was a major portion of the route and it was ice-locked eight or nine months of the year. The problem was solved in wartime by building 1800 kilometers of railway lines across swampy land, through the taiga and over permanently frozen soil, connecting Vorkuta with the Soviet railway system.

A log-cabin research station in "old" Vorkuta, belonging to the Academy of Sciences, maintains constant observation over the condition of the soil that lies within the permanently frozen region. Across the river is the newer part of town, where pithead installations and huge dumps give the tundra the appearance of an old established coal field. The newer Vorkuta mines are mechanized to a considerable extent. The population of Vorkuta already numbers tens of thousands of persons who live in one- and two-story log-built houses. Despite the exotic nature of the Arctic tundra, this town is gradually beginning to resemble a community in the temperate zone.

Magnesium

FOR those who have not yet discovered what magnesium has to offer and are therefore not aware of its potential uses and advantages, L. M. Oldt, The Dow Chemical Company, has written an article entitled, "Magnesium—Lightest of Structural Metals." It appears in the February, 1946, issue of *Southern Power and Industry*.

Magnesium has a specific gravity of 1.74 and when alloyed with other elements, chiefly aluminum, manganese, and zinc, is transformed into the lightest of commercial structural metals. In its alloyed state, magnesium is an exceedingly versatile metal and readily lends itself to all the usual forms of fabrication such as casting, extruding, forging, rolling, forming, spinning, riveting, and welding.

Magnesium alloys may be sand-cast in green- or dry-sand molds, cast in permanent molds, or die-cast. In general, magnesium foundry practice is similar to that used for other metals.

In those applications which require lightweight, high strength, good machinability, and resistance to shock, magnesium-alloy castings are ideally suited. They have been effectively used in aircraft engines, aircraft landing wheels, in portable tools, and in high-speed rotating and reciprocating parts such as are used in the printing and textile industries.

Magnesium forgings made from extruded stock have good fatigue strength and are therefore well-suited to parts which must withstand repeated stresses. Better and more uniform mechanical properties are obtainable with magnesium forgings than are possible in heat-treated castings. Their soundness also makes them desirable for applications which require pressure tightness. Typical uses of magnesium forgings are aircraft-engine bearing caps, bearing housings, valves and pump bodies, supercharger parts, hydraulic cylinders, and a variety of miscellaneous control levers, and fittings.

In the form of extrusions, magnesium may be obtained in a wide variety of standard and special shapes, such as slender rods or tubes, bars, angles, channels, I-beams, or moldings.

Magnesium extrusions have found application in a variety of aircraft parts, manually handled and portable equipment, the framework of bus and airplane seats, and bus and trailer body frames.

Magnesium sheet and plate are well-suited to the manufacture of parts which must be formed, drawn, or welded, and yet be as light as possible. In the aircraft industry it has been

used for wings, wing tips, ailerons, fairings, oil and fuel tanks, floor plates, ducts, seats, and numerous other applications. Magnesium sheet and plate have been used in such diverse applications as canoes, rowboats, wheelbarrows, seating equipment, dock boards, baby strollers, venetian blinds, bus and trailer bodies, and many other products.

Because magnesium does not readily lend itself to severe cold-forming, such operations are therefore usually accomplished at elevated temperatures (600 F). Advantages derived from the hot-forming method are: Parts in magnesium may usually be formed in one operation which would require two or more operations in other metals; the intermediate annealing processes are unnecessary; the necessity of multiple dies for deep-drawn parts is also eliminated; and allowance for springback is greatly reduced.

The property of ultra lightness makes magnesium alloys a desirable structural material. It was used extensively in the aircraft industry and the portable-tool industry. Magnesium is now being successfully used for such other types of portable or handling equipment as conveyers, hand trucks, and can forks.

Other outstanding characteristics of magnesium are its machinability, rigidity, and ease with which it is joined. Like other metals, magnesium is subject to corrosion. For the majority of uses, however, adequate surface protection is obtained by the use of suitable paints.

A variety of special and ornamental finishes are available where appearance and sales appeal of magnesium articles must be considered. These processes include mechanical, chemical, and electrochemical methods, as well as a variety of painting systems.

The magnesium alloys developed thus far are not as hard as steel alloys, and therefore would not be used in those applications which require exceptional hardness, as in certain types of gears. In general, however, most of the alleged limitations or disadvantages of magnesium which were advanced chiefly during the formative years of the industry have been surmounted.

Kilgore-Magnuson Bill (S. 1850)

CURRENT developments in science legislation are regularly reported in *Science*, published by the American Association for the Advancement of Science. In the issue of March 1, Howard A. Meyerhoff, executive secretary, A.A.A.S., reviews the background of legislation now pending and summarizes the Kilgore-Magnuson bill, S. 1850, in a report, "The National Science Foundation: S. 1850, Final Senate Bill," which is helpful to engineers who wish to keep informed on this important matter.

For the complete text of S. 1850 and additional information regarding it, readers are referred to Senate Subcommittee Report No. 8, "National Science Foundation," Feb. 27, 1946, print containing S. 1850, which can be obtained from the Government Printing Office, Washington, D. C.

The *Science* article by Dr. Meyerhoff, slightly abridged, follows:

Although science has played an important role in many government departments, it was not until 1945 that it featured in Congress. About three years ago Senator Kilgore, of West Virginia, drafted a bill for which scientists and the Congress were not prepared. Its premature appearance and its defects, in combination, were more than this bill could survive. One of the unfortunate aftermaths of this first science bill was a suspicion of all proposed legislation, coupled with a prejudice against anything which Senator Kilgore might introduce in the scientific field. These suspicions engendered by the first science bill have seriously retarded progress in the consideration of the several bills introduced into Congress during 1945.

CHRONOLOGY OF SCIENCE LEGISLATION

Chronologically the first of these to appear was a bill (S. 825) introduced by Senator Byrd on April 4, 1945. Briefly, it proposed the establishment of a Research Board for National Security as an independent government agency. Its principal objective was the creation of an agency competent to formulate scientific research for the Departments of War and Navy. A somewhat similar bill was introduced into the House by Representative May on June 11, but here it was proposed that the Research Board be set up by the National Academy of Sciences in co-operation with the War and Navy Departments. It was in July that the Senate really warmed up to the idea of introducing science legislation. On the 9th, Senator Fulbright proposed, in S. 1248, to set up within the Department of Commerce a Bureau of Scientific Research to encourage research and to develop inventions, products, and processes which might prove useful to business. The proposed Bureau would absorb the Office of Production Research and Development of the War Production Board and the National Inventors Council. On the 19th, Senator Magnuson introduced S. 1285, which translated into legislation the major recommendations of Vannevar Bush's Report to the President, "Science: the Endless Frontier." Four days later Senator Kilgore introduced a more comprehensive bill, S. 1297, embracing many of the features of S. 1285, but including the social sciences and some patent proposals. S. 1297 differed from S. 1285 in one other important particular, namely, in proposing that a National Science Foundation be administered by a Director rather than by a Board of unpaid, part-time scientists.

The overlapping objectives of the four Senate bills made the need for further study and co-ordination evident, and during the months of August and September Senators Fulbright, Kilgore, and Magnuson agreed to hold joint hearings on their respective bills. Meanwhile, the President's message of September 6, although designed to stress the need of science legislation and to harmonize the proposals obtained in the several bills, in effect magnified the differences among them and created a rift that made S. 1285 and S. 1297 rival bills. Each of them slowly acquired partisan support among scientists, and the October hearings widened, rather than healed, the rift.

Starting early in August the American Association for the Advancement of Science interested itself in the legislation and made an earnest effort to secure improvements which were deemed vital if either S. 1285 or S. 1297 were to be enacted into legislation. By means of a questionnaire sent to members of the Council and distributed ultimately to approximately 600 scientists in different parts of the country, the Association obtained a sufficiently reliable background of opinion to enable it to take an active part in the hearings and in senatorial staff conferences. Over 90 per cent of the returns indicated definitely that American scientists want a National Science Foundation, and the Association regarded this strong desire of its membership as a mandate to work for the best possible legislation.

Approximately 100 scientists and a few laymen participated in the October hearings. The selection of witnesses was, for the most part, made without reference to the views which they held and, indeed, an earnest effort was made to obtain every shade of opinion from university, industrial, and government scientists, as well as from agencies and businesses whose chief concern is the application of science. Of all the witnesses, only one went on record as being opposed to the establishment of a National Science Foundation. A clear majority favored the inclusion of the social sciences in the Foundation. A majority

likewise favored the Board form of administration, as opposed to administration by a Director appointed by the President. Except among the industrial groups, the interest in patent problems and issues was comparatively low, but there was a clearly defined concern about the free dissemination of results of government-supported research.

For a time it was hoped that these consolidated hearings might result in a consolidated bill, but the combination of circumstances led in the opposite direction. The old prejudice against Senator Kilgore led to a misrepresentation of his position, particularly among those scientists who, for one reason or another, favored the Board form of administration, the exclusion of the social sciences, and the exclusion of patent provisions from the bill. During November this rather miscellaneous group formed the Committee Supporting the Bush Report, which came out definitely against S. 1297 and for S. 1285. The majority of scientists, on the other hand, found themselves unable to give unqualified support to either of the two bills and so worked consistently for still better legislation in the form of a new bill. Their efforts led to the introduction of S. 1720 on December 21. This bill, introduced by Senator Kilgore, with Senators Johnson, Pepper, Fulbright, and Saltonstall as co-sponsors, embodied so many changes and improvements that it provided a new basis of discussion.

In January, through the intervention of Senator Thomas, of Utah, representatives of the Committee Supporting the Bush Report were brought together with Senators Kilgore and Saltonstall, and several modifications in the provisions of S. 1720 were proposed and carefully considered. On February 9 everyone concerned agreed upon a somewhat revised version of S. 1720, which was introduced into the Senate as S. 1850 on February 21, and which will be known as the Kilgore-Magnuson Bill. In addition to Senators Kilgore and Magnuson, Johnson, Pepper, Fulbright, Saltonstall, Thomas, and Ferguson are sponsoring S. 1850,

SUMMARY OF BILL S. 1850

This bill establishes a National Science Foundation with broad powers and objectives. The affairs of the Foundation will be directed by an Administrator who will be aided—and checked—by a National Science Board, composed of high-ranking scientists selected by the President. The Board shall have a voice in the selection of the Administrator, and it shall have direct access to the President and to the Congress, both in reporting on the achievements of the Foundation and in supporting or opposing specific acts of the Administrator. Within the Foundation there will be divisions of (1) mathematical and physical sciences, (2) biological sciences, (3) social sciences, (4) health and medical sciences, (5) national defense, (6) engineering and technology, (7) scientific personnel and education, (8) publications and information. Additional divisions not to exceed three in number, may be created by the Administrator, by and with the advice of the Board. Inasmuch as the work of the natural science divisions will be guided by the carefully prepared reports of Vannevar Bush and his committees, the work of the division of social sciences is restricted until a comparable report is prepared, detailing the proposed research in this general field. Public ownership of patents and free dissemination of information arising from Foundation-supported research are provided for, but the Administrator is given latitude and discretion in regard to patents, specifically in contracts which involve substantial contributions to the development of particular inventions, discoveries, and developments on the part of the organizations to which such contracts are given.

Apart from the solution of the controversial issues, the new bill provides for a broad program of support for research and for scientific education and co-operation. Scrupulous care has been taken to leave research and researchers free and unrestricted, save as the Foundation may deny support when particular projects are unsound or unwarranted. International co-operation and interdepartmental co-ordination within the United States Government are other important adjuncts to the proposed science legislation.

OTHER BILLS PENDING

Although the phraseology of S. 1850 has proved acceptable to scientists and to the Senators involved, it may yet undergo major or minor changes when the bill is presented to the full Senate Committee on Military Affairs, and again when it is reported out of Committee and onto the Senate floor. Once proposed legislation reaches the floor of the Senate, amendment is an uphill job, but it must be remembered that a rival bill was recently introduced by Senator Willis (S. 1777), and that there may be some pressure from this group to secure modifications in the bill which comes from the Committee on Military Affairs, with concurrent support from the Committee on Commerce. However, it has been admitted by several of the cosponsors of S. 1777 that their support was given primarily because of the rift among the scientists. S. 1777 provided for further study of the situation and commanded their support for this reason. The reason no longer exists, and it is hoped that this group of Senators will support the legislation which the vast majority of scientists approve.

The fate of the new bill in the House of Representatives is unpredictable. The May Bill (H.R. 3440) has already been passed, but it provides solely for military research. The new Senate bill incorporates many of the provisions of the May Bill applying them specifically to the Division of National Defense; and it may be hoped that the supporters of the May Bill will find the Kilgore-Magnuson document acceptable as a substitute and as an amplification of the Government's research program. The Luce Bill (H.R. 5332), which was introduced on February 1, 1946, does not appear to be rival legislation. It proposes the creation of a Department of Science and Research, with a Secretary of Science and Research in the Cabinet. The proposed divisions of the new department do not include all of the fields of science, and the proposed groupings are open to serious criticism. The Luce Bill offers nothing which scientists can support and creates the serious hurdle of obtaining recognition of a new Cabinet post. It is safe to conclude that none of the science legislation currently before the House will prove competitive; but, on the other hand, there is reason to believe that the Representatives are more interested in economy than they are in the support of science. There has been comparatively little opportunity for members of the House to familiarize themselves with the thinking that has gone into the Kilgore-Magnuson Bill, and it is clear that an important job of education lies ahead and that the scientists are best qualified to undertake it.

At a time when our allies in the late war are giving generous support to science, and when American science has lost 100,000 or more recruits in scientific research through the operation of Selective Service, it is appropriate to endorse and actively to support legislation which is designed to supplement the contributions which our industries and our educational institutions are making to scientific research. A Senator or a Representative can take intelligent action only when he is informed of the action his constituents want him to take. A resolution gets some attention, a letter from an individual is more informative, a telegram is somewhat better than a letter, but a personal call on his Senator now or his Representative a little later is the best way that an individual scientist can take positive action to insure the passage of the Kilgore-Magnuson Bill, S. 1850.

Solar Home

MANY innovations have been incorporated in what is regarded as America's first prefabricated solar home erected in April, 1945, near Rockford, Ill., according to an article in *Sheet Metal Worker*, November, 1945.

The house has been planned to take maximum advantage of heat from the sun for heating in winter as well as providing the greatest possible protection from the sun's rays in summer. Windows occupy a large area of the south wall. All the important living, dining, sleeping, and recreation rooms are arranged along this wall. The large area of glass is protected from the summer sun by overhanging eaves and vertical adjustable louvers. The extent of the overhang is fixed to allow a maximum of the sun's rays to penetrate the rooms with southern exposure in the winter and exclude them as much as possible in the summer. A service corridor along the north wall provides protection from winter winds. An additional summer cooling effect is provided by maintaining a thin layer of water on the built-up roof.

A closed or radiant warm-air heating system serves the house. Air is heated in a gas-fired unit and is circulated through tile ducts under the floor. The warm air passes from the supply ducts through perforations in their top walls into floor tiles and flows across to the south side of the house. It then enters the return ducts and travels back to the unit where it is heated for further recirculation. Dampers control the circulation to various parts of the house.

Loss of heat from the ducts to the foundation is minimized by use of mineral-wool insulation.

Lower type ventilation is provided. The covers are fixed and screened and ventilation is controlled by a solid fixed panel.

Erection was unique. The duct system, the finished floor, the fireplace, and the chimney were all in place before the roof units arrived. The house, 58 ft 6 in. long and 22 ft 6 in. wide, was erected on a 144 × 164-ft lot. A poured concrete foundation extends below the frost line and it has a solid masonry floor. The foundation walls are 12 in. thick at their base graduated to 8 in. and then to 4 in. in the section above the ground. Bolted to the foundation are the wall panels of the house.

Supply and return lines rest on a layer of gravel placed in the space enclosed by the foundation walls. Cement is used to build up the remaining space to the level of the supply lines. A thin layer of grout is laid, and on top of this the floor tiles proper are placed.

Mastic is applied to the joints of the tile supply and return lines when they are being set into position. Tarpaper wrappings are then applied to prevent the gravel from entering the ducts. In this first house, sheet-metal inserts were used in connecting tiles to prevent mortar from dropping into the ducts and preventing the free passage of warm air. Mortar is applied between the joints of the floor tiles and then sanded.

Wall and partition panels (modular units), roof panels, and built-in units were taken from the plant to the site by truck. The house was erected in about 14 hours.

In the house there are 1200 tile ducts, weighing approximately 35 lb each—42,000 lb in all. The total weight of the prefabricated units was 34,000 lb exclusive of the floor.

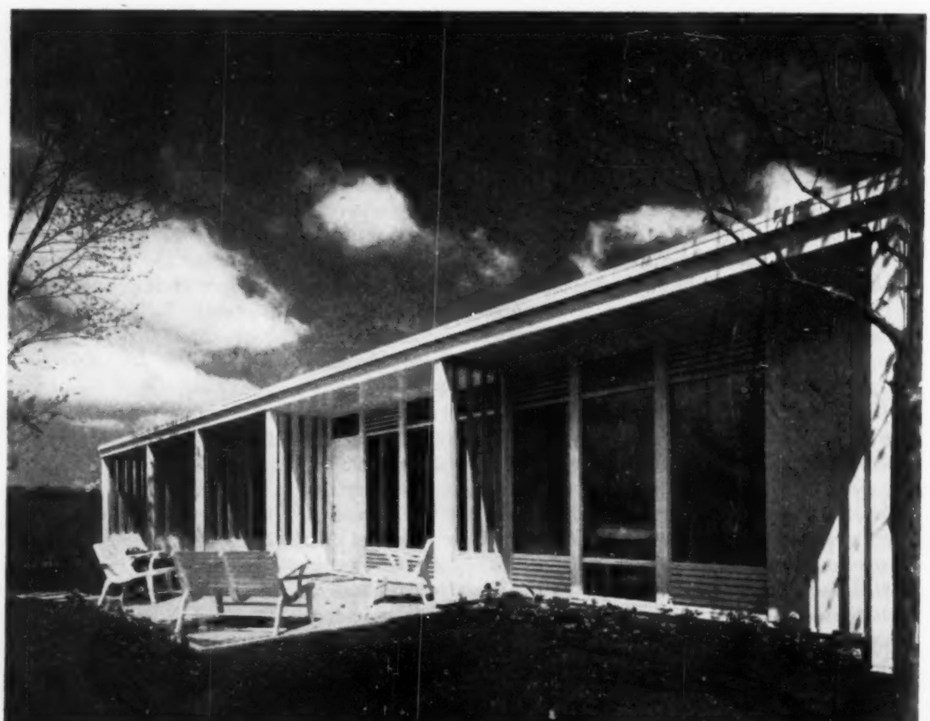


FIG. 7 VIEW OF SOUTH WALL OF SOLAR HOUSE

Standardized Steam Turbines

THE first standardized steam turbine, a 30,000-kw machine for electric power generation is in production at the South Philadelphia plant of the Westinghouse Electric Corporation, L. E. Osborne, member A.S.M.E., vice-president of the corporation, revealed recently. The unit is the result of a long-felt need to remove the "custom-made" label from such machines.

This development was brought about by a joint committee organized by The American Society of Mechanical Engineers and the American Institute of Electrical Engineers. The A.S.M.E. Committee on Standardization of Steam Turbines, under the chairmanship of K. M. Irwin, member A.S.M.E., was appointed in February, 1943, and held meetings on April 14, May 19, and Oct. 6, 1943. At the May, 1943, meeting a draft proposal was presented. This proposal was sent to a large group of manufacturers and users of steam turbines for criticism and comment. The replies received were reviewed at the Oct., 1943, meeting of the committee, and it was recommended that copies of the proposed standard be sent to the British and Canadian interests for their information. This meeting was attended by M. S. Oldacre in his capacity as chairman of the Subcommittee on Standardization of Generators which had been appointed by the A.I.E.E. at its 1943 summer convention.

The report of the A.S.M.E. Committee, with tabulation of proposed steam-turbine ratings, was submitted to the A.S.M.E. Council in November, 1943, for approval, with the recommendation that publication be withheld until the A.I.E.E. subcommittee had completed its work on generators and that the two then be published as a joint turbine-generator standard. This report was approved by the Council in December, 1943.

Early in 1944 it was found necessary to give additional consideration to certain phases of the proposed turbine-generator standard. The A.I.E.E. and A.S.M.E. committees accordingly held individual and joint meetings in Pittsburgh on June 21, 1944, and in Cleveland on September 13, 1944; and each committee submitted its report to its respective sponsor organization in October and November, 1944.

On the recommendation of the A.S.M.E. Standardization Committee, the Council of the Society approved the tabulation of turbine-generator ratings and characteristics on Feb. 23, 1945, and on the recommendation of the A.I.E.E. Standards Committee it was approved by the Board of Directors of the A.I.E.E. on Feb. 27, 1945. This led to the formation of the Joint A.I.E.E.-A.S.M.E. Committee on Steam Turbine-Generators.

The six sizes of turbines decided upon by the committee as being within the range of the most common of the larger power-plant sizes and therefore most suitable for standardization, have been confined to condensing units for operation at 3600 rpm, between the ratings of 11,500 kw and 60,000 kw. This is sufficient range to provide power for cities from 10,000 to 50,000 population.

Standardization of turbine sizes will result in reduced prices and shorter deliveries than for nonstandard machines, and should permit a decrease in time required by manufacturers to submit performance estimates. The standardization program will in no way hinder production of any size steam turbine-generator needed for purposes for which the standard specifications might not be suited. Further, the standard is not intended to prevent the purchase of duplicates of machines already installed, and for which designs and patterns are available.

Research, too, will be stimulated by this development owing to the amount of effort that can be diverted from custom designing to research.

In addition to the Preferred Standards for Turbine-Generators, which were prepared by the joint committee, Standard Specification Data for Generators have been prepared by the A.I.E.E. Group of the Joint committee for separate publication by the A.I.E.E. The data cover detail information that will assist in the standardization of the generators.

New Snow-Removal System

AN under-the-pavement heating system that keeps sidewalks and driveways warm enough to melt snow as it falls and prevents formation of hazardous ice has been designed by E. C. Schwebel, member A.S.M.E., plant engineer at the Wadsworth Watch Case Company, Dayton, Ky.

The system was installed in three locations around the plant and reports indicate that the new method not only kept the sidewalks and loading areas open at all times, but it eliminated the maintenance and equipment cost attendant to manual snow-removal.

One installation involved a sidewalk 11 ft wide and 200 ft long. The others were a loading area and an ambulance entrance.

Steam was piped to the wrought iron coils buried under the pavement, from the plant's boiler room. Adequate provisions were made for condensate drainage, and to prevent the condensate from freezing the system was kept in continuous operation.

FIG. 8 COILS OF WROUGHT IRON HEATING PIPE UNDER PAVEMENT KEEP AMBULANCE ENTRANCE OF THE WADSWORTH WATCH CASE COMPANY FREE OF SNOW AND ICE DURING THE WINTER

Engineering data compiled by A. M. Byers Company, Pittsburgh, Pa., indicates that a melting rate of one inch per hour is considered to be a practical goal for such snow-removal systems.

Pressure Welding

A BRIEF account of the work on Recrystallization Welding carried out by the British Non-Ferrous Metals Research Association for a Joint Committee of the Association and the British Welding Research Association, reported by R. F. Tylecote, in the Transactions of the Institute of Welding, appears in the Jan. 18, 1946, issue of *Metal Industry*. In this work attempts were made to weld overlapping sheets of superpurity aluminum, commercial-purity aluminum, seven aluminum-base alloys, and three magnesium-base alloys, by the simultaneous application of heat and pressure at temperatures below the melting points. The overlapped specimens were compressed between heated dies, the contact diameter of which was 0.45 in., and brought up to the required temperature by heat transfer from the dies. During this time pressure was being applied through the dies. In the process the dies were pressed into the sheet producing a deformation, the extent of which was measured by the percentage reduction in thickness of the overlapped specimens between the dies.

SURFACE PREPARATION

A variety of surface-treatment methods were tried and it was found that a combination of scratch-brushing or pickling followed by scratch-brushing gave the lowest values of contact resistance. This combination was then used in the preparation of the surfaces to be pressure-welded.

To determine the range of pressure and temperature within which pressure welding would occur, the results of tests on the different alloys were shown by plotting temperature against pressure, the diagrams also including the deformations that were produced. Two curves were drawn in each diagram, one through the minimum deformations at which welds, however small, were obtained, and another through the points which had a deformation of 80 per cent, representing the maximum deformation permissible for practical purposes. The upper ends of these curves were fixed by the solidus temperature of the alloy concerned. It was found impracticable to weld above this

temperature owing to the sudden complete collapse of the material and fouling of the dies with the resultant liquid phase. From the liquidus temperature the two curves gradually sloped downward to lower temperatures as higher pressures were applied. The maximum pressures employed were about 120,000 psi. In many of the alloys welding could probably be continued down to room temperature if higher pressures could be used. However, it is doubtful whether pressure above 100,000 psi would ever be practicable.

Closer investigation of the deformation produced under the conditions employed showed that there was a deformation gradient, with the maximum deformation occurring at the interface and diminishing toward the surface in contact with the dies. At the welding temperatures employed the clad Al-Cu-Mg alloy tended to behave as a homogeneous material. All the alloys were used in the annealed condition. In some tests with hard-rolled specimens it was found that the specimens were annealed at the higher welding temperatures, while at lower temperatures some of the hardness was retained and stronger welds were produced. It was difficult, however, to divorce the effect of cold work on the strength of the sheet, which influences the strength of the weld, from any effect the condition of the sheet may have had on weldability.

WELD STRENGTH

The strength of the welds tended to increase with welding time. In these experiments pressure was reduced after an initial application to produce a constant deformation. "Post-heating" at solution temperature benefited welds in the age-hardening alloys. In the case of aluminum, welds were obtained in less than 15 sec, but only after a welding time of 15 sec or more could consistent values be obtained. In the case of Al-Cu-Mg-Mn alloy to B.S.S. $5L_4$ at a welding temperature of 495 C, the strength of the welds reached a maximum at a welding time of 10 sec, after which the weld strength deteriorated until at 30 sec the strength was about half that at 10 sec. Beyond 30 sec the weld strength gradually improved to the values obtained with normal welding times.

It was found that where pickling and scratch-brushing gave the same contact resistance, the scratch-brushed surfaces gave the stronger welds. This was thought to be due to the roughness of the scratch-brushed surfaces.

The mechanical strength of the welds, determined by both shear and tensile tests with double-V specimens, compared favorably with spot welds. But a fair comparison is difficult because of the uncertainty regarding the true area of the pressure welds in which the total area of contact is not necessarily equal to the total area of the weld.

Microscopical examination of cross sections of pressure welds showed that recrystallization across the original interface had occurred in some cases. In other cases, however, no recrystallization had taken place. Welding had, in fact, occurred at a temperature below what was regarded as the recrystallization temperature of the alloy, and it would appear that recrystallization is not an essential accompaniment of pressure welding. It may be that where no recrystallization takes place, the interface is converted by pressure-welding into something approaching a grain boundary. Many welds showed fragments of oxide film along the line of the original interface.

Summing-up, the Al-Mn alloy as well as the Al-Mg-Si alloy, the Al-Cu-Mg-Mn alloy, aluminum-clad alloys and commercial-purity aluminum are the easiest to pressure-weld. It is possible to produce welds with a deformation as low as 20 per cent. With the first two alloys it may even be possible to produce welds on a commercial scale with a deformation of from 5 to 10 per cent. The minimum welding pressure for most alloys lies in the range of $1^1/_2$ to 7 tons per sq in.

Hot-Air Turbine Plant

PROF. J. ACKERET and Dr. C. Keller, in the Jan. 4, 11, and 18, 1946, issues of *Engineering*, give an excellent account of the experimental 2000-kw closed-cycle hot-air turbine plant constructed at the Escher Wyss works.

Commencing with the construction of the test plant in 1936, it was first operated in 1939 and functioned without many defects. During recent years, as a result of measurements made during many hundred hours of trial operation, various parts of the plant have been redesigned and systematically improved.

Briefly the plant operates as follows: A hot-air turbine drives on one side a compressor, while its surplus energy drives a generator on the other side. About 60 per cent of the total turbine output is required for driving the compressor and 40 per cent is delivered to the generator. Relatively cool air delivered from the compressor is passed through the heat exchanger in which it is preheated to about 350 C by the turbine exhaust. It then flows into the air-heater tubes in which its temperature is further raised to 650 to 700 C. Oil firing was adopted for the airheaters, a new kind of burner being used. Under a pressure of about 24 atm abs the hot air is delivered to the turbine in which it expands and does work. On leaving the turbine the air temperature is still approximately 400 C and the pressure 6 atm abs. The heat of this air is supplied to the air delivered from the compressor. After further cooling in the precooler, the cooled air exhausted from the turbine flows back to the compressor inlet, and is returned to the circuit at a pressure of 6 atm abs.

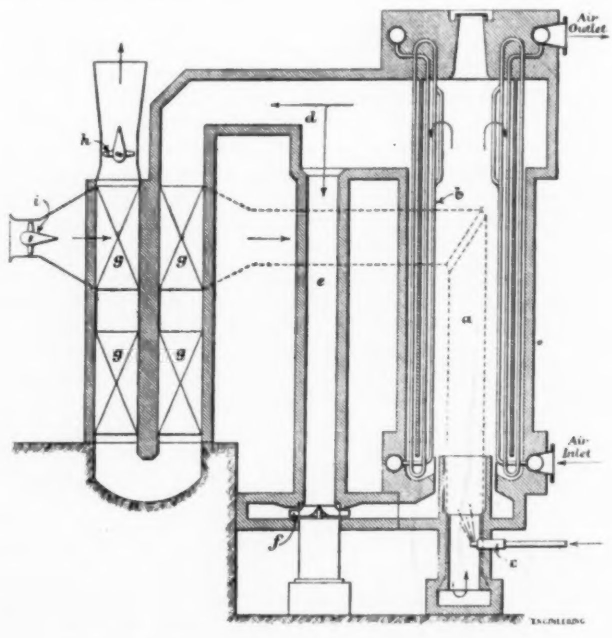


FIG. 9 DIAGRAMMATIC SECTION THROUGH AIR HEATER

The air heater, see Fig. 9, in an Ackeret-Keller (AK) plant is employed in the same way a boiler is used in a steam plant, but differing in that the working medium enters the air heaters in a highly preheated condition, having first passed through the heat exchanger. The air, the pressure of which has been raised in the compressor from 6 atm abs to 24 atm abs and its temperature having been ra·sed in the preheater to 365 C, enters the system of tubes at the bottom of the air heater.

Referring to Fig. 9, tubes *b* are arranged radially around

the axis of combustion chamber *a*. Fuel oil is injected intermittently by pumps similar to those used with Diesel engines through four burners *c*. The flame is directed upward in the tall combustion chamber *a* and the combustion gases traverse the spaces between various rows of tubes as a countercurrent to the air, leaving the heater at a temperature of about 550 C, also at the upper end. As indicated by arrows *d* part of the gases are drawn through flue *e* by fan *f* and returned to the furnace in order to reduce the temperature of the latter, while the remainder flows through the air preheater *g* in which it gives up heat to air employed for combustion, so that this air enters the combustion chamber at a high temperature. Fan *h* draws the combustion gases through the air preheater while fan *i* delivers air through the preheater to the furnace.

The turbine actually comprises two sections: A high-pressure section which drives the compressor at a speed of 8000 rpm, and a low-pressure section which drives the generator at 3000 rpm. Expansion in the turbine takes place without intermediate heating. The casing and rotor are made of chrome-nickel steel for withstanding high temperatures. Because of the small heat drop in the turbine, which is approximately one quarter of that in steam turbines, only 12 stages are employed; six each in both the high- and low-pressure sections. The working air flows from left to right through various guide blades and runner wheels expanding from the admission pressure and temperature of 24 atm abs, 650 C down to 12 atm abs, 500 C, at the outlet; all stages have full admission. The output of the rotor at full load is 3000 kw. Since the low-pressure turbine operates at temperatures of about 500 C only, the use of special alloy steels is unnecessary. The air leaves the low-pressure turbine after having been expanded from about 12 atm abs, 500 C down to 6 atm abs, 400 C. This rotor develops 2000 kw.

In its present form, the heat exchanger is a typical tubular apparatus operating on the countercurrent principle. Air from the low-pressure turbine passes over the exterior of the tubes, and the compressed air which leaves the compressor at 24 atm abs, flows as a countercurrent inside the tubes.

In passing through the heat exchanger the expanded air is cooled down to about 100 C and is then led through a water-cooled precooler of similar design to the heat exchanger and then to the compressor inlet, where its temperature is 20 C.

The compressor is a multistage axial-flow unit, in which a number of impellers are arranged in series and fitted with blades of airfoil section. Efficiencies are high, due to the small deflection and accurate profiles of the blade sections. A high, an intermediate, and a low-pressure casing make up the compressor. The rotors all run at 8000 rpm. After passing through the compressor, the air is led back to the heat exchanger, and after preheating passes to the inlet of the air heater where the initial point is again reached.

Results obtained during official performance trials indicate that higher efficiencies can be obtained with this plant than with a steam-turbine plant of the same output. Fig. 10 shows the over-all thermal efficiency determined from the output measured at the turbine coupling and the measured fuel consumption. It was ascertained for the normal full load, $^3/_4$ load, $^1/_2$ load, and approximately $^1/_4$ load.

The authors say that in comparison with modern steam plants, the possible sources of trouble are much less in a plant of the type described. All the regulating apparatus can be installed in a closed casing outside the circuit and only cold air passes through it. The fact that high pressures need not be employed to attain high thermal efficiencies simplifies the operation in comparison with modern superpressure steam power plants using working pressures of 100 atms abs, and even higher.

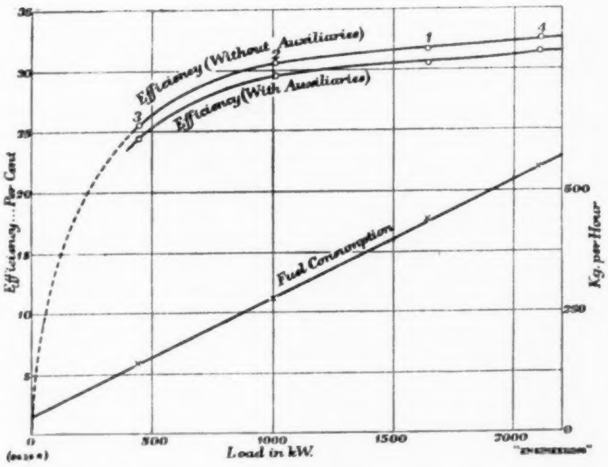


FIG. 10 OVER-ALL THERMAL-EFFICIENCY CURVES

In addition to its use for stationary plants, the AK system is also suitable for ship propulsion, particularly in conjunction with variable-pitch propellers.

Textile-Research Progress

THE extent of the field of textile research in Sweden is briefly summarized by Alex. Engblom, Fellow A.S.M.E., and works manager of the Boras Waferi Aktiebolag, Boras, Sweden, in a reprint entitled, "Research and Progress in the Textile Industry."

In it the problems of textile technology are discussed under two principal headings—basic and directed research.

Basic research, according to Mr. Engblom, is of purely scientific character, works with distant aims, and in general is concerned with the solution of more fundamental problems. Directed research is more practical in nature, since it seeks principally to solve problems directly connected with the different processes of production.

A few examples of the interesting results achieved in the sphere of basic textile research are revealed in the paper; and under directed textile research, some indications of the work carried out at the Textile Institute in Boras and at the State Testing Stations are presented.

Stainless Steel Handbook

PUBLICATION of a 100-page pocket-size handbook present ing information on 26 types of stainless steels has been announced by Allegheny Ludlum Steel Corporation, Brackenridge, Pa.

The handbook contains a 44-column finder chart giving analyses, properties, hot-working temperatures, and heat-treatment of the different types, including a general discussion of types and properties of stainless steel. A table of corrosion resistance of four leading types of stainless steel to 220 chemicals and common materials is followed by a 20-page section which describes stainless-steel products, and clad steel (Pluramelt).

Fabrication methods and procedures occupy 40 pages, and the final section contains general reference tables of bar weights, weights of sheet, weights of tubes, feet per pound of wire, decimal equivalents of fractions of an inch, and temperature conversion.

In General

Antifriction Die Sets

TWO new types of die sets have been invented by Lempco Products, Inc., Bedford, Ohio, with guide pins that will not "freeze" due to friction developed at high speeds.

The round guide-pin style employs ball-bearings, and the square guide-pin model utilizes roller-bearings. Both were designed for use on high-speed punch presses but they may be used to good advantage wherever ordinary die sets are employed.

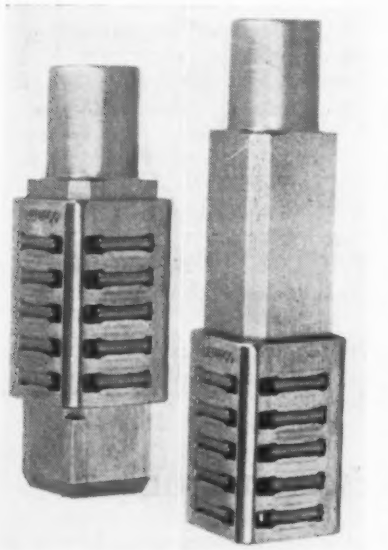


FIG. 11 ANTIFRICTION SQUARE GUIDE-PIN ROLLER-BEARING ASSEMBLY

Play between guidepost and bushing is kept to an absolute minimum, which results in longer life for the die and greater production between die grinds. These new precision-made die sets open and close freely by hand, thereby greatly reducing die-setters' time. No jacks, pry bars, or similar tools are needed.

Photography

Soon to be made available by The Glenn L. Martin Company, Baltimore, Md., is a new process by which metal, wood, cloth, leather, plastics, or almost any other surface can be usable for photographic reproduction.

Basis of the process is an emulsion, a jelly-like substance which, when heated to a temperature of 125 F, becomes a liquid and may be applied to the surface of the material, thus sensitizing it for photographic print use.

FIG. 12 PHOTOGRAPHS MAY BE PRINTED ON VARIOUS MATERIALS BY APPLYING THE NEW PHOTOGRAPHIC EMULSION ON THEM

Electron Microscope

The State Engineering Experiment Station at the Georgia School of Technology, Atlanta, Ga., announces the installation of a $13,000 electron microscope which is capable of magnifying images as much as 20,000 times.

This scientific instrument will enable experimenters to obtain much basic information on many problems in the fields of medicine, biology, bacteriology, agriculture, metallurgy, textile fibers, and ceramics. The microscope will be used in co-operative research with other schools and universities located in the South.

Vibration Exciter and Calibrator

An electrodynamic exciter-calibrator, designed by the vibration division of the MB Manufacturing Company, Inc., New Haven, Conn., has the power to vibrate mechanical structures and parts to destruction, thus pointing out weak spots by these failures. It enables the test operator to excite a product or part to its resonant modes of vibration with a pure sine-wave force that can be controlled in both frequency and amplitude; and it provides a means for studying the nature of these modes, and the most practical type of correction.

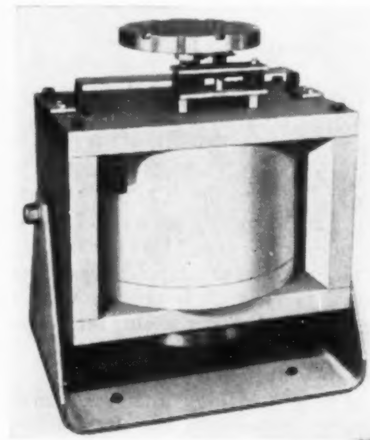


FIG. 13 VIBRATION-EXCITER AND CALIBRATOR

In addition to duplicating age-loosening of parts that would usually be achieved in several months of operational tests, the machine aids in locating noise sources.

Metal Disintegrator

A new and improved type of metal disintegrator which rapidly and safely removes broken taps and drills from work in progress, thus saving the piece, has been developed by the Drafto Corporation, Cochranton, Pa.

Tests show that the new disintegrator, working on the electrical "sputtering" principle, will remove broken drills or taps from work without injuring the metal regardless of the work-piece metal hardness. The new machine can also be used as a drill.

Industrial Eyesight Tests

Ingenious methods of visual classification for job placement are discussed in a study, "Methods of Testing and Protecting Eyesight in Industry," prepared by and available from Policyholders Service Bureau, Metropolitan Life Insurance Company, New York, N. Y.

The report discusses the purpose and scope of industrial eye examinations, including job analysis, placement, and rehabilitation of the visually handicapped. It also sets forth the pro-

cedure for installing an industrial eye program and describes the functions of the eye and the techniques employed in visual testing.

Radar for Night Boats

First major marine installation of radar equipment as a navigational aid on "long-distance commercial passenger-carrying service" is under way on the Old Bay Line's Baltimore-Norfolk night boat, City of Richmond, it was revealed by Westinghouse Industrial Electronics Division, Baltimore, Md.

The new unit—which incorporates up-to-the-minute refinements of war-developed radar—will provide navigational and anticollision protection in darkness, fog, and all other varieties of bad weather for a distance of 100 yards to 32 miles.

New Thread Ring Gage

A new type of adjustable thread-ring gage, made in conventional thread-ring sizes, but employing a unique design, is currently being introduced to industry by N. A. Woodworth Company, Detroit, Mich.

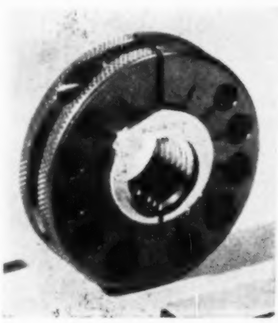


FIG. 14 NEW RING GAGE

It is said that this gaging instrument assures and maintains roundness through the maximum range of adjustment because of its design which distributes wear over 360 deg, or the full thread. Adjustment is made along the helix angle of the thread thus preventing a jump lead at the adjusting slot of the gage. An aluminum-alloy outer body halves conventional weight.

Lubrication Training Schools

A national program of lubrication training schools in upward of forty cities, where returned veterans and others will be trained as lubrication specialists to fill key jobs in automobile service establishments, was announced recently by the Alemite Division of Stewart-Warner Corporation. Classes have begun in several cities and are scheduled to open in others shortly.

In addition to learning the mechanics of actual lubrication, men attending the schools will be given instruction in service merchandising, record-keeping, customer-contact and sales promotion, lubricant chemistry and selection, and equipment care and maintenance.

Standardization of Bearing Sizes

SKF Industries, Inc., has recently urged the nation's motor and machine manufacturers to join a movement to standardize sizes of ball and roller bearings. S. F. Wollmar, executive vice-president of SKF, said that approximately 40,000 sizes and makes of antifriction bearings are now being produced. If a uniform system of basic sizes were adapted, it might be possible to turn out about 2000 sizes of bearings.

This standardization would reduce over-all costs, speed delivery of bearings to prime reconversion centers, aid young industries, and broaden American participation in world reconstruction.

Twin-Valve Pump

Candler-Hill Corporation, Detroit, Mich., announces the development of a dual-valve pump. Now under test by Army, Navy, and commercial air lines, the pump delivers a constant flow of fuel at almost constant pressure and volume. This is accomplished by an ingeniously different development in relief-valve design for the dual-valve incorporates two relief valves within its mechanism.

Optical Micrometer

An optical micrometer for accurately measuring the thickness of transparent plastics (and glass) in places inaccessible to the ordinary mechanical micrometer has been developed by Aireon Manufacturing Corporation, Burbank, Calif.

Worked out on the principle of apparent depth, the thickness in central portions of large sheets of lucite, plexiglass, or plate glass, whether curved or flat, can easily be obtained with this new micrometer.

FIG. 15 OPTICAL MICROMETER

Lightweight Radial Saw

A lightweight portable 12-in. radial saw, which it is said will save 25 per cent or more of the usual power-saw time on the average industrial or other production cutting job, has been announced by the American Saw Mill Machinery Company, Hackettstown, N. J.

The new radial saw is made principally of light nonrusting magnesium so that the unit complete with carrying frame and $1^1/_2$-hp electric motor weighs approximately 200 lb. It is so compact that it is easily carried by two men, through a 30-in.

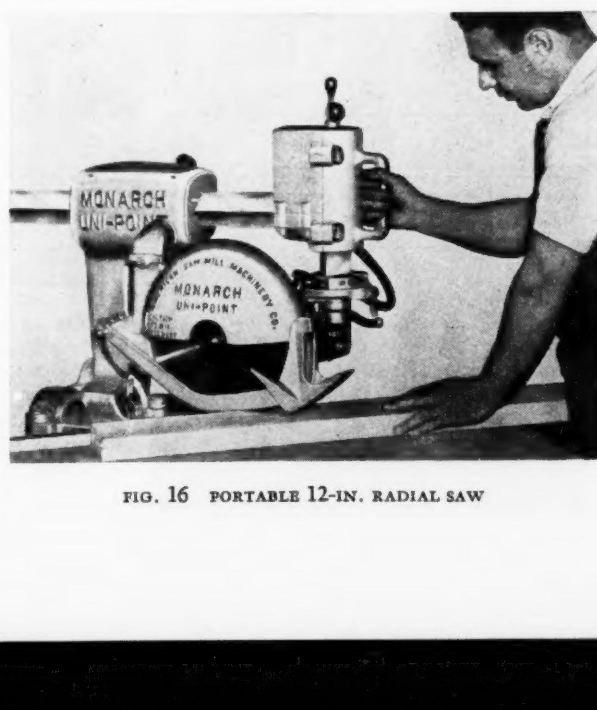


FIG. 16 PORTABLE 12-IN. RADIAL SAW

doorway, yet it has a 3×16-in. crosscut and $20\frac{1}{2}$-in-wide ripping capacity, and it will handle all the different kinds of work that heavy stationary radial saws will handle.

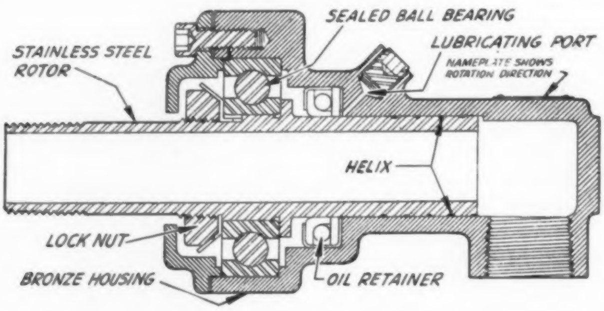


FIG. 17 SECTION THROUGH NEW TYPE OF ROTATING WATER JOINT

New Rotating Water Joint

A new type of rotating water joint for cooling revolving shafts, cylinders, or drums, has been developed by the Deublin Company, Northbrook, Ill. The water joint will also efficiently handle liquids for heating up to 200 F.

Leakproof, corrosion proof, frictionless, and more sturdy, the joint utilizes a helical groove on the rotor which runs counter to the direction of rotation. The sweeping action of the helix prevents leakage between shaft and housing as well as keeping foreign objects from lodging between the two surfaces. Precision machining leaves maximum clearance between the shaft and housing of 0.0005 in. Rotor concentricity is held to 0.001 in. total dial-indicator reading.

Pendant Control

A new type of pendant control for all cut master vertical turret lathes—the 30-in., 36-in., 42-in., 54-in., 64-in., and 74-in. sizes—has been announced by The Bullard Company, Bridgeport, Conn.

Speeds are rapidly selected by means of dialing. When in operation and a change of speed is desired, the switch lever is thrown into brake position, the change of speed quickly dialed, and the lever thrown back into clutch position. Gears are quietly and almost instantaneously shifted through electrically controlled hydraulically operated mechanisms. Self-interlocking design provides protection for the proper selection of gears.

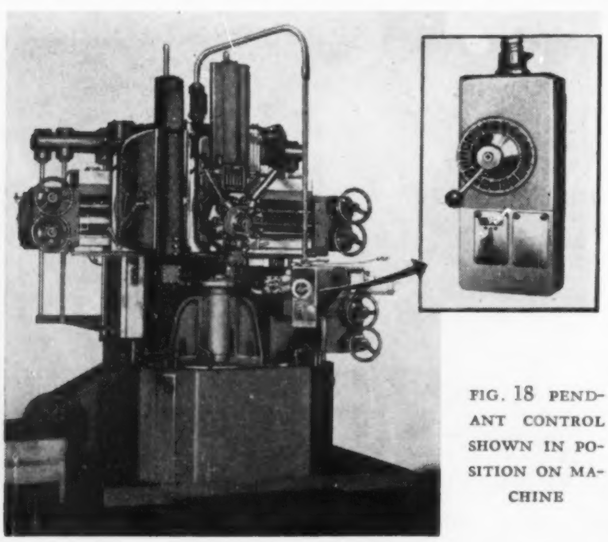


FIG. 18 PENDANT CONTROL SHOWN IN POSITION ON MACHINE

Home Workshop Tool

A compact and inexpensive power grinder, sander, buffer, and power saw for home workshops, modelmakers, and light manufacturing has been announced by Parlex Tool Company, Ingelwood, Calif.

The basic tool is an abrasive grinder on one end and a sanding disk with adjustable work rest on the other. Either the grinding wheel or the sanding disk may be replaced with buffing or polishing wheels for a second combination. The third adaptation makes up into a power saw. A fourth combination is provided in the unique design of the saw table so that dado heads may be used for routing.

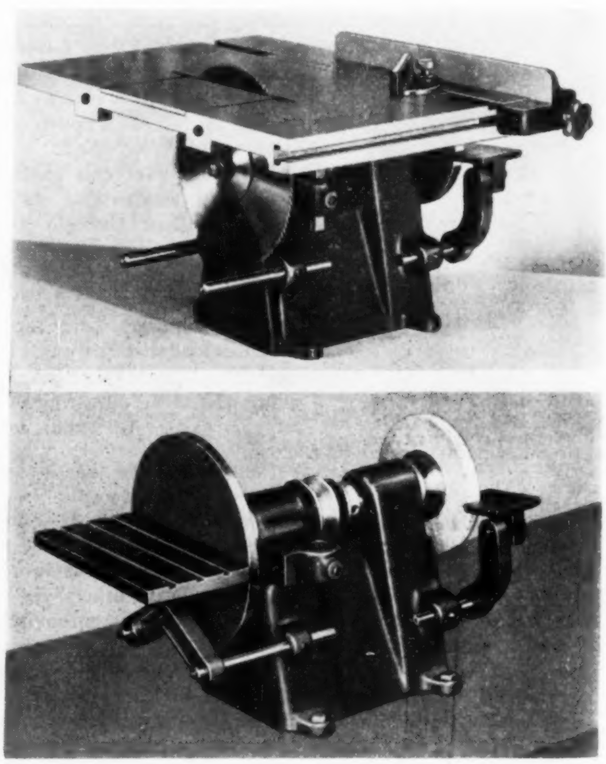


FIG. 19 COMBINATION POWER GRINDER, SANDER, BUFFER, AND POWER SAW

New Interference Viewer

Uniformly accurate measurements of gage blocks, anvils, sealing surfaces, and other precision articles are claimed for the Optron Interference Viewer, an instrument of unique design, announced by Optron Laboratory, Dayton, Ohio.

The surface being examined—either for flatness or for size—is both illuminated and viewed on a line perpendicular to the surface. Hence no error can be introduced by viewing the surfaces from an angle different from the angle of illumination. A pattern appears the same to different observers, making instruction—or checking by more than one observer simple and straightforward. Distortion of the pattern which usually exists in conventional interferometers is completely eliminated.

REVIEWS OF BOOKS

And Notes on Books Received in the Engineering Societies Library

Endless Horizons

Endless Horizons, by Vannevar Bush. Public Affairs Press, Washington, D. C., 1946. Cloth, 6 × 9 in., 182 pp., $2.50.

INTO a collection of articles sp eches, and excerpts from reports covering a period from January, 1933, to October, 1945, assembled in book form under the title, "Endless Horizons," with an introduction by Frank B. Jewett, and published by the Public Affairs Press, Vannevar Bush, director of the Office of Scientific Research and Development, has distilled a vast quantity of sound philosophy, hardheaded horse sense, and matured wisdom, and has issued challenge after challenge to his fellow scientists and engineers to intensify their efforts on behalf of their fellow countrymen to raise the standard of living and work for national security and world peace. Reading this remarkable collection, engineers will recognize the forward-looking *Atlantic Monthly* article of August, 1945, "As We May Think," excerpts from the report to the President, July, 1945, "Science: the Endless Frontier," which set up the needs and means of achieving a national research foundation; the stimulating American Engineering Council address of January, 1939, "The Qualities of a Profession," and several speeches that were liberally reported in the press at the time of their delivery.

Dr. Bush begins the collection by placing a very irritating burr under the saddle of complacency in an article, written in 1933, "The Inscrutable Past." In an Edward Bellamy vein, as though he were writing a century hence, Dr. Bush recites the trials of men of 1933, as illustrated in the life of a "professor in some northern urban university, and wonders "that they could have been apparently content with their mode of life, its discomforts, and its annoyances." In 1933, with nothing worse to contemplate than a world-wide economic depression in an era of physical plenty, with prosperity always just around the corner, the stimulating irony with which Dr. Bush jibed at complacent satisfaction with things as they were then provokes a desire to live long enough to see things as they might be if science were given half a chance.

The contrasting piece, "As We May Think," which follows immediately, looks into the future and describes the memex, that gadget of Utopia, which brings to instant use within the compass of an article of furniture no larger than a desk not only the knowledge of all time but the means by which a thought pattern can be established and recalled and elaborated; the mechanical memory and memorizer, tireless and unforgetting, that will vastly multiply the productivity of future thinkers and workers in science.

There follow six chapters taken from the report to the President, proposing a federally financed national research foundation, the realization of which may come to pass through legislation currently under discussion at Washington. The sections of the report here reprinted constitute the fundamental doctrine, broadly sketched and wisely argued, with estimates of costs and clearly phrased principles of operation, of a science development program for raising the standard of living, safeguarding the health and security of the nation, and providing means for the survival of civilization through world peace.

Four chapters devoted to research on military problems, the control of atomic energy, research and the war effort, and the teamwork of technicians reflect the author's observations on science in a democracy at war which is now moving into the days of peace with the sobering realization of the role it has to play to maintain that peace. No one can read these chapters without admiring the maturity of wisdom that is the fruit of knowledge, experience, and thoughtful contemplation of realistic and idealistic points of view.

Chapter 13, "The Qualities of a Profession," takes the reader back again to 1939 and the American Engineering Council which ceased to exist shortly thereafter. Perhaps the American Engineering Council was doomed to failure in any event—it had inherent organizational weaknesses, and at least one rock on which it split was the antithesis of the professional idea which Dr. Bush set forth in his address. Forces now at work encourage the hope that what the American Engineering Council sought to accomplish may come to pass under other influences. When that day comes we may substitute the name by which the organization which shall exert these influences will be known for the American Engineering Council; but we shall not find it necessary to change the address in other respects. It epitomizes what engineers most earnestly desire for their profession.

Rereading the closing paragraphs of that address, one can recapture the thrill of inspiration that electrified those who heard them spoken in 1939. "Professional status," said Dr. Bush, "rests in perpetuity, not on transient law, not on the cruder machinations of the ancient guilds, not on an exclusive control of those having a specialized and necessary knowledge; but upon the respect and fundamental support of the people who are served, who only in the long run can insist upon the maintenance of prerogatives, and confer honor, recognition, and special privileges in society upon the members of a profession."

"Will engineers support such a program?" he asked; and he closed with the admonition: "And to those in the ranks who may not yet have seen the light, I would preach the doctrine, without pulling any punches, without mincing any words, that the path of professional attainment lies open before them, that it is a thorny path that is easily lost sight of among the rocks and rubbish, that it can be adhered to only by sacrifice and by support of those who lead the way, that it is a long path which leads down into the valley into which the sun does not shine, but that it leads at last to the heights—to the heights of true professional attainment, where honor and individual recognition by fellows is the real reward, and where the watchword is that old, old, theme which has never lost its power, and which may yet save a sorry world, simple ministration to the people."

In a world torn with domestic strife spawned by selfish interest and greed, these words kindle a beacon of hope. They should be read and pondered constantly by engineers and by their leaders.

Dr. Bush's Edison Medal address, "Our Tradition and Opportunity," (1944), and the report, "The Need for Patent Reform" (1935), which constitute chapters 14 and 15, deal with qualities in the American way of life that have provided us with a high standard of living and the means, through patent protection, by which those who have contributed toward the advancement of that standard have been incited to exercise their best efforts. "We sadly need," says Dr. Bush, "to return to the realization that the pioneer is a benefactor, against whom the door of opportunity must not be closed."

"Science for World Service," the last of the collection of papers that have been previously published, is an address before the New York Herald-Tribune Forum on Current Problems, October, 1945. Dr. Bush relates his comments to two matters of current and world-wide concern, the United Nations Organization and the atomic bomb. "We must be prepared to recognize," he declares, "that no short-range self-interest of the United States can be allowed to stand in the way of full and sincere collaboration with other nations in the furtherance of peace." It is a "startling fact," he says, "that the United States today . . . . . could turn aggressor, devastate the centers of the world with atomic bombs, and . . . . . impose its will on all nations. The power is thus the power to rule the world. The opportunity is the opportunity not to use that power for that purpose . . . . . The United States will use the opportunity, not the power."

"How shall we use that power?" he asks. "Using atomic energy," he states, "is a dangerous undertaking. But that energy must be brought to use, for it can ultimately bring all mankind more ease and peace than we have ever known."

Without going into Dr. Bush's comments on the international problem of atomic-bomb secrecy, it will be useful to quote his views in general on the free interchange of knowledge. "As an engineer," he says, "I have good reason to know that the free exchange of ideas and knowledge is the first requirement of progress. We had such a system before the war and under it American science and engineering led the world. It must be restored, for only by the cross-fertilization of brains do we breed great thinking, and the peaceful control of the energy of the atom will demand much great thinking. Therefore I hope to see the United States make the first great move toward the renewal of international exchange of scientific knowledge. I believe we should undertake to share with our world partners all of our basic scientific knowledge of atomic energy." This is far from "giving away the secret of the bomb." This first step "of suggesting full interchange on the basic science of the atom," he argues, is important, "for to take it would indicate strongly that we wish to proceed down the road of international collaboration."

As an epilogue to this collection of previously published papers Dr. Bush concludes with a chapter called "The Builders," in which he likens the advancement of the boundaries of knowledge and the building of the structure of organized science to "the exploitation of a difficult quarry for its building materials and the fitting of these into an edifice." A great variety of persons labor in the quarry, in fitting the stones, in giving the structure meaning, and in ministering to those who are engaged in the project. But there are more than these. "There are also the old men, whose days of vigorous building are done, whose eyes are too dim to see the details of the arch or the needed form of its keystone, but who have built a wall here and there, and lived long in the edifice; who have learned to love it and who have even grasped a suggestion of its utimate meaning; and who sit in the shade and encourage the young men."

So ends a stimulating group of papers, which, as Dr. Jewett says in the introduction, "give but a general outline of the range of Dr. Bush's interests. However, they show something of his basic philosophy and of his methods of approaching the one well throughout and consistent; the other, independent, direct, and incisive." And, it may be added, they reveal the author as a scientist and engineer, and, not the least of all, a poet.—G. A. S.

Applied Energy Conversion

APPLIED ENERGY CONVERSION. By Bernhardt G. A. Skrotzki and William A. Vopat. McGraw-Hill Book Co., Inc., New York, N. Y., 1945. Cloth, $5^1/_4 \times 8^1/_4$ in., 509 pp., illus., $5.

REVIEWED BY A. G. CHRISTIE[1]

THE subject of power production is of such keen interest to most engineers that each new book on this subject has a special appeal. This is particularly the case since the art of power-plant design and the economy of operation have undergone great changes during the past two decades.

One will naturally ask, "What contribution to our knowledge is made by this new book?" In the first place, it presents the present state of the art and describes the equipment now generally in use in a lucid and concise manner. The authors have shown good judgment in their selection of material.

A special feature of this book is the mount of space devoted to the discussion of the economic problems of equipment selection and plant performance, which extends over almost one fifth of the text. This subject appears to be a particular interest of the authors as the subject is covered much more extensively than in other books on power plants. One finds an extensive use of the load-duration curve for various analyses. This very useful curve has not been as widely used in America as in foreign countries. Hence, many data on load factors of sections of plant, on costs of carrying peak loads, and on sectional load growth are not as well known by operators as would be desirable. The wide use of the input-output curves to solve economic problems is another commendable contribution. The authors should have indicated in an appendix how this curve and its mathematical expression may be derived for a given set of operating conditions.

The book opens with a discussion of fuels and their combustion. Weight relations instead of mols are used in fuel calculations, which is regrettable as the latter is becoming the acceptable practice in the several branches of engineering. Furnace equipment, steam generators with economizers, superheaters, air preheaters, and water treatment are considered in a descriptive manner. A chapter is devoted to prime movers, principally steam turbines. Condensers and their auxiliaries, feedwater heaters, and boiler feed pumps are next discussed. Power plants and their cycles follow.

Notable omissions are the presentation of a discussion of the important plant elements of piping and instruments. Both of these assume increased importance in new high-pressure, high-temperature stations.

One chapter each is devoted to Diesel engines, to hydraulic power plants, and to recent other power developments. This material is quite general, which suggests a limited experience of the authors with the problems involved in such developments.

In general, the power-plant-design sec-

[1] Professor of Mechanical Engineering, The Johns Hopkins University, Baltimore, Md. Fellow A.S.M.E.

tion of the book is largely descriptive and lacks the extended design data and performance figures one finds in other texts on this subject. One is therefore led to the conclusion that aside from the discussion of plant economics previously noted, the book will serve best as a textbook for students rather than a reference book for plant designers. The large number of problems accompanying each chapter will also enhance its value as a student text.

Books Received in Library

ART OF PLAIN TALK. By R. Flesch, foreword by L. Bryson. Harper & Brothers, New York, N. Y., and London, England, 1946. Cloth, 5 × 8¹/₄ in., 210 pp., tables, $2.50. Some two years ago Mr. Flesch published his Ph.D. dissertation, "Marks of Readable Style." Being a thesis it was not a very readable book, so he has rewritten it in simple language. This book is the result. It is not a book on basic English. Scientific studies of readability have produced a formula based on sentence length and on the number of affixes and personal references included. The main feature of this book is this formula which is intended only as a yardstick. Readers are warned not to wallow in the little rules and computations and thus lose sight of the principles of plain English. Examples of difficult material and the same rewritten in simple English are included.

AVIATION FACTS AND FIGURES 1945. Edited by Aircraft Industries Association of America, Inc., R. Modley, editor. McGraw-Hill Book Co., Inc., New York, N. Y. and London, England, 1945. Cloth, 5³/₄ × 9 in., 173 pp., tables, $2.50. This is a comprehensive reference handbook of pertinent data and statistics on aviation as a whole, covering the entire field; the book lays particular emphasis on the aircraft industry. It deals fully with the civil and military use of aircraft, with exports, service facilities, and the relation of aviation to other means of transportation.

WILLIS RODNEY WHITNEY, Pioneer of Industrial Research. By J. T. Broderick, with foreword by K. T. Compton. Fort Orange Press, Albany, N. Y., 1945. Cloth, 5¹/₂ × 8¹/₂ in., 324 pp., illus., $3. Willis R. Whitney's major achievements were made as director of the Research Laboratory of the General Electric Company. This biography covers his life and activities up to and during this period, with some emphasis on his personal research and discoveries.

Library Services

ENGINEERING Societies Library books may be borrowed by mail by A.S.M.E. members for a small handling charge. The Library also prepares bibliographies, maintains search and photostat services, and can provide microfilm copies of any item in its collection. Address inquiries to Mr. Ralph H. Phelps, Acting Director, Engineering Societies Library, 29 West 39th St., New York, N. Y.

A.S.M.E. BOILER CODE

Proposed Revisions and Addenda to Boiler Construction Code

IT IS the policy of the Boiler Code Committee to receive and consider as promptly as possible any desired revisions of the rules and its codes. Any suggestions for revisions or modifications that are approved by the Committee will be recommended for addenda to the code, to be included later in the proper place.

The following proposed revisions have been approved for publication as proposed addenda to the code. They are published herewith with corresponding paragraph number to identify their location in the various sections of the code and are submitted for criticism and approval from anyone interested therein.

It is to be noted that a proposed revision of the code should not be considered final until formally adopted by the Council of the Society and issued as pink-colored addenda sheets. Added words are printed in SMALL CAPITALS; words to be deleted are enclosed in brackets [ ]. Communications should be addressed to the Secretary of the Boiler Code Committee, 29 West 39th St., New York 18, N.Y., in order that they may be presented to the Committee for consideration.

PAR. P-23(a) Revised.

(a) For inspection purposes, the minimum thickness of pipe wall to be used for piping at different pressures and for temperatures not exceeding those given for the various materials in Table P-5 shall be determined by the formula given below:

$$t_m = \frac{PD}{2S + 0.8P} + C, \quad \text{or}$$

$$P = \frac{2S\,(t_m - C)}{D - 0.8\,(t_m - C)}$$

where t_m = minimum pipe wall thickness, inches.[1]

The minimum thickness used in the formula shall in no case be more than the minimum thickness resulting from the application of the tolerances given in the Code specification for the material to be used, including tube material which is to be used for piping.

P = maximum internal service pressure, pounds per square inch, at the operating metal temperature for which the value of S is taken from Table P-5.[2] The value of P in the formula shall not be taken at less than 100 for any condition of service or material.

D = outside diameter of pipe, inches.

S = allowable stress due to internal pressure at the operating temperature in the material, pounds per square inch (See Table P-5).[3]

C = allowance for threading, mechanical strength, and/or corrosion, inches.

For steam piping connected to the boiler drum or to the superheater inlet header up to the first stop valve in each connection, the value of P shall be not less than the lowest pressure at which any drum safety valve is set to blow and the S value shall not exceed that permitted for the corresponding saturated steam temperature.

For steam piping connected to the superheater outlet header up to the first stop valve in each connection, the value of P shall be not less than the lowest pressure at which any valve on the superheater is set to blow, or not less than 85 per cent of the lowest pressure at which any drum safety valve is set to blow, whichever is greater, and the S value for the material used shall not exceed that permitted for the expected steam temperature.

For steam piping between the first stop valve and the second valve, when one is required by Par. P-303, the value of P shall be not less than the expected operating pressure or 85 per cent of the lowest pressure at which any drum safety valve is set to blow, whichever is greater, and the S value for the material used shall not exceed that permitted for the expected steam temperature.

[1] If pipe is ordered by its nominal wall thickness, as is customary in trade practice, the manufacturing tolerance on wall thickness must be taken into account. After the minimum pipe wall thickness t_m is determined by the formula, this minimum thickness shall be increased by an amount sufficient to provide the manufacturing tolerance allowed in the applicable pipe specification. The next heavier commercial wall thickness may then be selected from Standard thickness schedules as contained in ASA B36.10. The manufacturing tolerances are given in the several pipe specifications listed in Table P-5.

[2] When computing the allowable pressure for a pipe of a definite minimum wall thickness, the value obtained by the formulas may be rounded out to the next higher unit of 10.

[3] The factors of safety and allowance for joint efficiencies of welded pipe have been taken into account in the S values given in Table P-5. Where pipe is subjected to more than one "pressure-temperature" operating condition, the value of t_m shall be determined from the "pressure-temperature" operating condition which results in the maximum t_m, except as provided in (f).

FIG. P-9. To be deleted.

PAR. P-24. Revise first section to read:

Feedwater piping (Par. P-317) shall conform to the requirements of Pars. P-9 and P-300.

The minimum thickness shall be determined by the formulas in Par. P-23 or P-26 in which the values of P shall be not less and the values of S shall be not more than stated below:

(1) For piping between the boiler up to and including the required stop valve and the check valve, the value of P shall be not less than 1.25 times the lowest pressure at which any safety valve on the boiler drum or water space is set to blow;

(2) For piping between the check valve and the globe or regulating valve, when required by Par. P-317, and including any by-pass piping up to the shutoff valves in the by-pass, the value of P shall be not less than the pressure required to feed the boiler;

(3) The S values used shall not exceed that permitted for the temperature of saturated steam corresponding to the lowest set pressure of any safety valve on the boiler drum or to the maximum water temperature to be handled, whichever is greater;

(4) The value of P in the formula shall not be taken at less than 100 for any condition of service or material.

Add the following as the last section:

The provisions of Par. P-23(f) shall apply to feedwater piping.

PAR. P-25. Revise second section to read:

The thickness of all blowoff piping between the boiler and the valve or valves required by Par. P-311 shall be equal at least to that required for the feedpiping required by Par. P-24 for the feed line between the boiler and the required check valve, except that for pressures over 100 psi, the thickness shall be not less than that given for "extra strong" in Table 3 of Specification SA-53 and Table 2 of Specification SA-72.

PAR. P-186. Add the following as (c):

(c) A furnace in a Scotch-type boiler may be attached to an outwardly-flanged opening in a front tube sheet by a circumferential fillet weld, or in a boiler of this type, a furnace may be attached to either tube sheet by flaring the end which extends beyond the outside face of the head to an angle of 20 to 30 deg, and using a circumferential fillet weld, provided:

(1) The area of the head around the furnace is stayed by tubes or braces in accordance with the Code requirements; and

(2) The joint is wholly outside the furnace; and

(3) The throat of the full fillet weld is not less than 0.7 the thickness of the head; and

(4) The construction conforms in all other respects to Code requirements including welding, stress-relieving, etc., except that radiographing is not required.

PAR. P-291. Revise first sentence to read:

Each boiler shall have at least one water gage glass except that boilers operated at pressures over 400 psi shall be provided with two water gage glasses WHICH MAY BE CONNECTED TO A SINGLE WATER COLUMN, OR CONNECTED DIRECTLY TO THE DRUM IN WHICH CASE THE CONNECTIONS TO THE DRUM AND THE WATER GAGE GLASSES SHALL BE AT LEAST 2 FT APART. [on the same horizontal line with separate connections at least 2 ft apart or may be connected to the same water column.]

Insert the following as the third sentence of the first section:

Each water gage glass shall be equipped with a top and a bottom shutoff valve of such through-flow construction as to prevent stoppage by deposits of sediment and to indicate by the position of the operating mechanism whether they are in open or closed position. If stopcocks are used, they shall be of a type with the plug held in place by a guard or gland. The pressure-temperature rating shall be at least equal to that of the lowest set pressure of any safety valve on the boiler drum and the corresponding saturated steam temperature.

Add the following as the last section:

Straight-run globe valves of the ordinary type as shown in Fig. P-43A shall not be used on such connections.

PAR. P-299(d). Revise first section to read:

All valves and fittings on all feedwater piping from the boiler up to and including the first stop valve and the check valve (Par. P-317) shall be equal at least to the requirements of any Standard accepted by this Code for a pressure 1.25 times the maximum allowable working pressure of the boiler or 1.25 times the lowest set pressure of any safety valve on the boiler drum except as otherwise stated in (c) and for a saturated steam temperature corresponding to the set pressure of the safety valve or the water temperature, whichever is greater.

Insert the following as the second section:

All valves and fittings for feedwater piping between the required check valve and the globe or regulating valve, when required by Par. P-317, and including any by-pass piping up to and including the shutoff valves in the by-pass, shall be equal at least to the requirements of any Standard accepted by this Code for a pressure rating equal to the expected operating pressure required to feed the boiler when all safety valves are blowing and for a saturated steam temperature corresponding to the minimum set pressure of any safety valve on the boiler drum or the actual temperature of the water, whichever is greater.

PAR. P-302. Add the following:

The nearest steam stop valve or valves to the boiler drum shall have a pressure rating at least equal to the minimum set pressure of any safety valve on the boiler drum at the corresponding saturated steam temperature.

The nearest stop valve or valves to the superheater outlet shall have a pressure rating at least equal to the minimum set pressure of any safety valve on the superheater and at the expected superheated steam temperature; or at least equal to 85 per cent of the lowest set pressure of any safety valve on the boiler drum at the expected steam temperature of the superheater outlet, whichever is greater.

PAR. P-303. Add the following:

When a second steam stop valve or valves is required, it shall have a pressure rating at least equal to that required for the expected steam temperature and pressure at the valve, or the pressure rating shall be not less than 85 per cent of the lowest set pressure of any safety valve on the boiler drum and for the expected temperature of the steam at the valve, whichever is greater.

PAR. P-307(a). Revise last sentence to read:

Piping connections used primarily for continuous operation, such as deconcentrators on continuous blowdown systems, are not classed as blowoff but the pipe connections and all fittings up to and including the first shutoff valve shall be equal at least to the pressure requirements for the lowest set pressure of any safety valve on the boiler drum and with the corresponding saturated steam temperature.

PAR. P-317(a). In the first sentence, omit the words "(except gate valve)." Insert the following as the second sentence: "A typical arrangement is shown in Fig. P-43½.*

PAR. P-318. Add the following:

For boilers fired with fuels other than gaseous, liquid, or pulverized, if pumps only are used, one shall be steam driven.

PAR. H-24. Revise as follows:

H-24 *Area of Heads to be Stayed.* (a) The area of a segment of a flanged head to be stayed shall be the area enclosed by lines drawn in 2 in. from the tubes and 3 in. from the shell. FOR AN UNFLANGED HEAD THE AREA TO BE STAYED SHALL BE THE AREA ENCLOSED BY THE SHELL AND A LINE DRAWN 2 IN. FROM THE TUBES.

(b) FOR UNFLANGED HEADS IN WELDED BOILERS OPERATING AT NOT OVER 15 LB STEAM AND 30 LB WATER, STAYING IS NOT REQUIRED IF THE HEIGHT OF THE SEGMENT BETWEEN THE TOP OF THE TUBES AND THE UNDER PART OF THE SHELL DOES NOT EXCEED 1.25 p. FOR SUCH BOILERS BUILT WITH THE HEADS SET INSIDE OF THE SHELL PLATES SO THE DISTANCE FROM THE END OF THE SHELL TO THE OUTSIDE FACE OF THE HEAD IS AT LEAST THREE TIMES THE SHELL THICKNESS, STAYING IS NOT REQUIRED IF THE HEIGHT OF THE SEGMENT BETWEEN THE TOP OF THE TUBES AND THE UNDER PART OF THE SHELL DOES NOT EXCEED 1.5 p.

PAR. H-68(a). Revise item (3) to read:

(3) SAFETY VALVE RELIEVING CAPACITY (MINIMUM) IN POUNDS PER HOUR (AS DETERMINED ACCORDING TO PAR. H-53). [Capacity (for determining safety valve capacity) showing (*a*) square foot of heating surface, (*b*) 5 lb steam per sq ft, or (*c*) the greatest (maximum) output in Btu per hr (1000 Btu = 1 lb steam).]

PAR. H-79. Revise as follows:

H-79 *Longitudinal Joints.* Where fusion-welded steel plate heating boilers are made up of two or more courses, the welded longitudinal joints of adjacent courses shall be not less than 6 in. [90 deg] apart.

* A figure, illustrating Code jurisdictional limits for piping will be inserted.

PAR. M-4(c). Revise first sentence to read:

Fusion-welded joints shall conform to the requirements of Pars. P-101 to P-110 of Section I of the Code, or to the requirements given in Section IX of the Code FOR PAR. U-69 VESSELS.

PAR. M-4(d). Add the following sentence:

If the boiler is tested in accordance with Par. M-19, neither stress-relieving nor radiography of the welded joint is required except that if the tube ends are welded the boiler shall be stress-relieved.

PAR. M-5. Letter the present paragraph as (a) and add the following as (b):

(b) In a miniature boiler unflanged flat tube sheets may be inserted into the shell and welded for the entire thickness as shown in Fig. P-21(f) of Section I of the Code with a fillet weld having a throat not less than $1^1/_4$ times the thickness of the shell or tube sheet, whichever is smaller. The minimum thickness of unflanged welded tube sheets shall be $^5/_8$ in.

PAR. U-36. Add the following:

(m) *Conical Heads Under Internal Pressure.* Where the angle α does not exceed 60 deg, the following formulas shall apply:

$$t = \frac{PD}{2 \cos \alpha\, SE - 0.6P}, \quad \text{or}$$

$$P = \frac{2\, SEt \cos \alpha}{D + 1.2t \cos \alpha}$$

where t = minimum required thickness (exclusive of corrosion allowance) of head plate after forming, inches,

P = maximum allowable working pressure, pounds per square inch,

D = inside diameter of the cone at the point under consideration, measured perpendicular to the longitudinal axis, inches,

α = one half of the included (apex) angle of the cone at the center line of the head, degrees,

S = maximum allowable working stress as given in Tables U-2 or U-3, pounds per square inch,

E = lowest efficiency of any joint in the head (exclusive of the joint to the shell):
for riveted joints = calculated riveted efficiency;
for fusion-welded joints = efficiency specified in Pars. U-68 and U-69;
for Par. U-70 use the values of SE given in the paragraph.

Where the angle α exceeds 60 deg, conical heads shall be at least as thick as flat unstayed heads.

When α exceeds 30 deg, conical heads shall be attached to the shell by a knuckle complying with the applicable provisions of Par. U-38, and the knuckle section shall meet the thickness requirements for the knuckles of spherically dished heads, using the formula in (a) in which

$$L = \frac{D}{2 \cos \alpha}$$

and D = inside diameter of the cone at the point tangent to the knuckle measured perpendicular to the longitudinal axis, in inches.

In no case shall the knuckle thickness be less than the thickness of the cone.

PAR. U-68(g). Revise as follows:

(g) *Retests.* Should either the tensile joint specimen or the tensile weld metal specimen fail to meet the requirements by more than 10 per cent, no retests shall be allowed and the entire test plate shall be considered to have failed. Should the free-bend test specimen fail to meet the requirements by more than 10 per cent, a retest may be allowed at the discretion of the inspector if failure appears to have occurred due to permissible defects.

Should any of the specimens fail to meet the requirements by 10 per cent or less, additional specimens may be tested. The retests shall comply with the requirements.

Additional specimens may be cut from the same test plate,[4] in which case two specimens of each type of test which failed shall be tested; or they may be cut from a second test plate welded by the operator who welded the original test plate, in which case one tensile joint specimen, one tensile weld metal specimen, and one bend test specimen shall be tested, regardless of which specimen from the first plate failed. In the absence of the operator or one or more of the operators who prepared the original test plate, the inspector shall designate an operator who welded a portion of a main shell seam to prepare a second test plate.

Where the joint tensile specimen or the bend test specimen is tested in more than one part as permitted in (e) and (f), failure of one part shall be considered failure of the entire type test and retests shall be permitted as outlined above.

If the percentage of elongation of any tension test specimen is less than that specified and any part of the fracture is more than $^3/_4$ in. from the center of the gage length in the all-weld metal tension specimen, or is outside the middle third of the gage length of the joint tension specimen as indicated by the scribe scratches marked on the specimen before testing, the specimen shall not be considered as representative, the results may be disregarded, and a new specimen substituted. The new specimen may be taken from the original or a new test plate.

TABLES U-3 AND P-6. The allowable working stresses for aluminum bronze (SB-171) should be extended up to and including 450 F, at 10,000 psi.

SPECIFICATION SA-72. To make this specification identical with A.S.T.M. Spec. A72-45, there will be added new Pars. 1(b), 10, 11, 12, 13(c), 14(b); Par. 5(a) will be revised.

SPECIFICATION SA-96. In view of the adoption of A.S.T.M. Spec. A193-45T, this specification, and references thereto, will be dropped.

SPECIFICATION SA-106. To make this specification identical with A.S.T.M. Spec. A106-45T, revisions will be made in Pars. 1, 2, 3, 6, 7(a), 9, 10, 11(b), 13(c), 16(b), 17, Note 1, and Tables 1 and 2, omitting reference to Bessemer grade of pipe. The note following Par. 2(a) is to be retained.

SPECIFICATION SA-157. Revisions will be made in the Title and Pars. 1(a) and 5, and Note 1.

SPECIFICATION SA-158. Revisions will be made in the Title, Pars. 1(b) and (c), 5, S1, Table 1.

SPECIFICATION SA-182. Revisions will be made in the Title, and Par. 1(a).

SPECIFICATION SA-194. Revisions will be made in the Title and Par. 1(a).

SPECIFICATION SA-206. To make this specification identical with A.S.T.M. Spec. A206-44T, revisions will be made in the Title, Pars. 1(a) and (b), 5, 17(b), S1 and Table 1.

SPECIFICATION SA-216. Revisions will be made in the Title, Par. 1(a) and Note 1.

SPECIFICATION SA-217. Revisions will be made in the Title, Par. 1(a), Notes 1 and 2.

SPECIFICATION SA-233. This specification will be extensively revised to make it identical with A.S.T.M. Spec. A233-45T.

SPECIFICATION SB-12. To make this specification identical with A.S.T.M. Spec. B12-45, revisions will be made in the Title and throughout the text of the specifications the term "rod" will be substituted for "bar."

SPECIFICATION SB-42. To make this specification identical with A.S.T.M. Spec. B42-45, revisions will be made in Pars. 2, 7, 10, 13(a) and (b), 14(b), (c), (d), (e), Tables 1 and 2.

SPECIFICATION SB-43. To make this specification identical with A.S.T.M. Spec. B43-45, revisions will be made in Pars. 2, 7, 8, 14, 15(b), (c), (d), Tables 1 and 2.

SPECIFICATION SB-75. To make this specification identical with A.S.T.M. Spec. B75-45T, revisions will be made in Pars. 9, 13, 14, 17(b) and Table 2.

SPECIFICATION SB-98. To make this specification identical with A.S.T.M. Spec. B98-45, revisions will be made in Par. 1, and a new Par. 13 will be added.

SPECIFICATION SB-111. To make this specification identical with A.S.T.M. Spec. B111-45, revisions will be made in Pars. 3(a), (b), 8, 9, Table 1, and a new Par. 9 will be added.

SPECIFICATION SB-171. To make this specification identical with A.S.T.M. Spec. B171-45, revisions will be made in Par. 3(a) and Table 1.

A.S.T.M. SPECIFICATIONS A280-46T for Seamless Chrome-Molybdenum Alloy-Steel Pipe for Service at High Temperatures will be included in Section II of the Code with allowable working stresses the same as for Specification SA-206.

SPECIFICATION SA-213. Include a note to the effect that tubes complying with A.S.T.M. Spec. A199-44 will be acceptable as complying with the intent of Specification SA-213.

SPECIFICATION SA-214. This specification will be dropped, and a note included in Specification SA-178 to the effect that tubes complying with A.S.T.M. Spec. A214 will be acceptable as complying with the intent of Specification SA-178.

[4] Where two test plates are welded at the same time, one at either end of the same longitudinal seam, they may be considered as the same test plate.

A.S.M.E. NEWS

And Notes on Other Engineering Societies

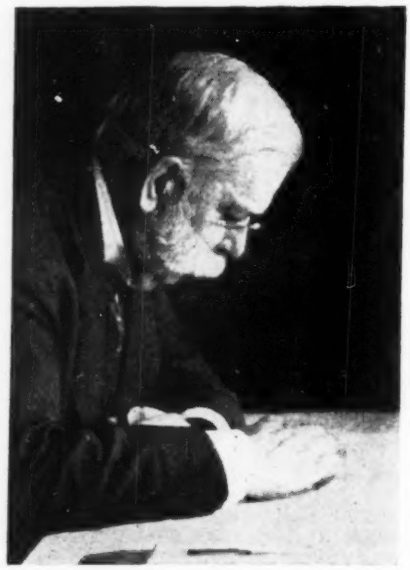
A.S.M.E. Holds Convocation to Honor George Westinghouse

THE American Society of Mechanical Engineers commemorated the achievements of George Westinghouse, past-president and honorary member, A.S.M.E., inventor, industrialist, and humanitarian, by a convocation of more than 60 scientists and engineers at the Engineers' Club, New York, N. Y., Feb. 26, 1946, on the occasion of the centennial year of his birth.

Inventor of the railroad air brake, staunch advocate of alternating current at a time when scientific opinion was heavily weighted against him, a liberal and progressive employer, George Westinghouse typified the ideal engineer. Born Oct. 6, 1846, he lived to take out more than 400 patents and organize more than a hundred companies. He was president of the A.S.M.E. in 1910 and when he died in 1914, it was said he died of overwork.

The purpose of the convocation was to call attention to George Westinghouse as the symbol of the engineer striving to improve human welfare, and to inspire the order of his genius and energy for solving the industrial problems that confront the engineering profession today.

At the speakers' table were D. Robert Yarnall, president A.S.M.E., who presided; Dean Dexter S. Kimball, past-president and honorary member, A.S.M.E., toastmaster; Samuel W. Dudley, dean, School of Engineering, Yale University, who spoke on "George Westinghouse—The Man;" A. N. Williams, vice-chairman of the board of the Westinghouse Air Brake Company, who spoke on "George Westinghouse's Position in the History of Transportation;" F. D. Newbury, vice-president, Westinghouse Electric Corporation, who spoke on "George Westinghouse—The Individualist;" Gwilym A. Price, president, Westinghouse Electric Corporation, and representitives of many national, technical, and professional organizations.



GEORGE WESTINGHOUSE

George Westinghouse—The Man

Quoting William Shakespeare, Dean Dudley said of George Westinghouse, "'His life was gentle, and the elements so mixed in him that Nature might stand up and say to all the world, This was a man!'"

"George Westinghouse," he said, "was such a man—dynamic, eager. One felt, rather than observed, the impact of his physical and mental vigor—the dominating control exercised by a courageous, disciplined spirit over the restless intellect and the no less energetic and powerful physique."

"To his associates in the workshop and in the office, these qualities commanded attention, admiration, and wonder. But to those who knew him in his home, among close friends, he disclosed a gentleness, a mixture of those elements of sensitivitity, sensibility, patience, and consideration for the little things that make life what it is, which drew men to him and inspired them. Lord Kelvin, a friend and co-worker for many years, said of him, 'George Westinghouse is, in character and achievements, one of the great men of our time.'"

George Westinghouse in Transportation

When George Westinghouse came on the scene of American railroad history, Mr. Williams said, locomotive development had advanced to the point where full utilization of motive power could not be achieved because there was no way of stopping and regulating a long train of cars.

"The urgency of the problem," he said, "was exemplified by the fact that over 600 patents had been taken out in quest of a solution. Within two years he invented, built, and demonstrated the air brake and thus unfettered transportation. This was the straight air brake, which was introduced in 1869.

"By 1887 train lengths increased to 50 cars and his quick-action automatic brake was accepted by competitive tests for trains up to this length."

"As freight-train lengths continued to grow to 75, then to 100 cars, constant improvement enabled the brake to perform satisfactorily for lengths far beyond the concepts of 1887."

Emphasizing the importance of American railroads, and George Westinghouse's contribution to the history of American rail transportation, Mr. Williams cited the case of German railroads in World War II. He said it was fortunate for us that the Nazi aggressor "concentrated his preparations on highways for his supply lines." Nazi neglect of the railroads, he asserted, was acknowledged as one of the major causes of his undoing on the Eastern Front.

George Westinghouse—The Individualist

If George Westinghouse could return to the scene of his work, Mr. Newbury said, he would get busy immediately on the organization of a Westinghouse Atomic Power Corporation, and he would possibly be puzzled by the fact that the United States would not allow him to do any such thing.

"George Westinghouse, I am sure," Mr. Newbury declared, "believed in increasing and equalizing earning power. I am equally sure he would be bewildered and annoyed if one of our modern disciples of government spending could tell the returned spirit of George Westinghouse that the government owed him a job or would otherwise maintain his purchasing power for him."

"George Westinghouse and his contemporaries," he continued, "looked to banking and industrial leaders to guide our material economy. He naturally and inevitably assumed his own large share of this responsibility."

"George Westinghouse lived his active life and did his work in a world that took private enterprise for granted," he asserted. "His times were still close enough to the European-planned economies of the eighteenth century from which we escaped by the determination and wisdom of the fathers of our Republic. They and the generation of George Westinghouse knew and feared the all-powerful government that planned economy requires. They valued the individual freedom that must be paid for by individual responsibility and sometimes dangerous insecurity. George Westinghouse, for one, was no timid advocate of security."

"Catalog Briefs"

IN this issue, beginning on page 37 through to page 60 of the advertising section, are listed 180 items about the latest available catalogs, bulletins, and literature covering engineering equipment, materials, supplies, and services. Use the coupon on page 39 to make a selection.

Detroit to Be Host to A.S.M.E. at 1946 Semi-Annual Meeting, June 17–20

PLANS for the 1946 Semi-Annual Meeting of The American Society of Mechanical Engineers with The Engineering Institute of Canada participating, to be held in Detroit, Mich., June 17 to 20, 1946, have crystallized to the point where an unusual meeting of wide technical interest is promised. Because special features are still pending, decision has not yet been made on the location of A.S.M.E. headquarters, but the Statler Hotel and the Book-Cadillac Hotel are under consideration.

E.I.C. to Participate

The Engineering Institute of Canada will participate in the A.S.M.E. 1946 Semi-Annual Meeting and it is expected that many members of the Border Cities Branch of the E.I.C., who work closely with the A.S.M.E. Detroit Section, as well as some of the national officers, will attend the technical and social events. Participation of the E.I.C. may include the presentation of papers at some of the technical sessions, but this part of the program has not yet been determined. The E.I.C., however, may secure the feature speaker for the dinner on Monday, June 17, 1946. It is expected that the speaker will be an engineer who will talk on Canada's experience with a national research agency.

Committee

Under the chairmanship of J. W. Armour, district manager, Riley Stoker Company, Detroit, Mich., approximately fifty members of the A.S.M.E. Detroit Section have been at work on committees of program planning, inspection trips, hotel arrangements, reception, and entertainment. Members of the general committee are: J. W. Armour, chairman, R. K. Weldy, vice-chairman; C. J. Freund, vice-chairman; Mrs. P. W. Thompson, chairman of the women's committee; A. C. Pasini, general secretary; H. E. Gandelot, chairman of information and registration committee; J. M. Geisinger, assistant secretary; R. H. Stellwagon, chairman of plant-trips committee; Tom Jeffords, vice-chairman; J. H. Spurgeon, chairman of printing and signs committee; R. F. Hanson, vice-chairman of plant-trips committee; H. S. Walker, chairman of finance committee; A. W. Honywill, chairman of technical-events committee; J. F. Jarnagin, chairman of publicity committee; and T. E. Winkler, chairman of entertainment committee.

Inspection Trips

As one of the great industrial centers of the nation, Detroit offers many points of interest to the engineer. Taking full advantage of its opportunities, the plant-trips committee under the chairmanship of R. H. Stellwagon, associate mechanical engineer, City of Detroit, has arranged a trip to the Willow Run airport and plant created under the stimulus of World War II.

Of special interest will be the visit to the Edison Institute and Museum, Greenfield Village, Dearborn, Mich., to see the notable exhibits covering the development of agriculture, transportation, industry, science, and education.

Adjoining the Museum, Greenfield Village contains many historical houses which have been moved to the site from many sections of the country by Henry Ford. Here will be found the courthouse from Springfield, Ill., where Abraham Lincoln practiced law; Edison's laboratory in which the first phonograph, incandescent lamp, microphone, and telephone transmitter were invented; as well as two Cotswold cottages which were built 250 years ago in England.

Technical Sessions

Eight groups of technical sessions are planned for which some thirty-five papers have already been selected. The following divisions will present papers: Fuels, Heat Transfer, Industrial Instruments and Regulators, Machine Design, Metal Cutting, Metals Engineering, Oil and Gas Power, Power, Process Industries, Production Engineering, and Rubber and Plastics. Two symposiums are planned: one on lake ore carriers and the other on the tank engine. A tentative list of papers will be published in the May issue of Mechanical Engineering.

Sight-Seeing Trips

Since the Semi-Annual Meeting will take place at the beginning of the vacation season in Michigan, many engineers and their wives will be able to combine the Meeting with a short vacation. Special attention is being given by the program-planning committee to allow members and guests sufficient time to enjoy the scenic beauties of Michigan. Sight-seeing trips are planned to Belle Isle, a beautiful island park in the Detroit River containing many miles of drives and walks, zoological gardens, and a horticultural building and aquarium. A steamer trip on the Detroit River to Lake Erie or Lake Huron and a motor trip to Windsor, Canada, via tunnel and return by the Ambassador Bridge is also planned.

CADILLAC SQUARE, DETROIT, MICH., WHERE A.S.M.E. 1946 SEMI-ANNUAL MEETING WILL BE HELD

President's Page

Nuclear Energy Applications

THE use of the atomic bomb in the closing days of the war has dramatized to the nation the great importance of science and engineering. It has called the attention of people who never before understood the uses of science to its far-reaching possibilities.

Engineers in industry have a great stake in the use and abuse of the applications that flowed out of the researches on which the destructive power of the atomic bomb was based.

The subject of atomic energy applications is a matter of important concern to our Society, as at least 98 per cent of these applications would have scientific and industrial rather than military use. Furthermore, the instrumentation and industrial processes developed to make atomic power may establish a new level of high performance in industry.

The American Society of Mechanical Engineers has now appointed a permanent Committee on Nuclear Energy Applications, to stimulate and develop a continuing program dealing with the industrial applications of nuclear energy, consisting of the following: Alex D. Bailey, chairman, A. L. Baker, G. B. Pegram, A. R. Stevenson, Jr., W. I. Westervelt, Adm. T. A. Solberg, U.S.N., and Capt. J. B. Cochran, U.S.N.

The civilization and happiness of this nation may be advanced by the wide uses of the results of research in nuclear physics which, at the proper time, it is hoped, may be released by our government for industrial development.

In so far as military uses are concerned, it behooves engineers as citizens to help our government strengthen the hands of the United Nations Organization, into whose safekeeping has been placed the responsibility for preventing the misuse of this world-shaking discovery.

D. ROBERT YARNALL, *President*, A.S.M.E.

International Forum to Commemorate Life of George Westinghouse

THE high light of the program commemorating the centennial of the birth of George Westinghouse, past-president and honorary member A.S.M.E., great inventor and industrialist, will be a Science and Engineering Forum to be held in Pittsburgh, Pa., May 16 to 19, 1946. This announcement was made by Gwilym A. Price, president, Westinghouse Electric Corporation, before a convocation of engineers and former associates of George Westinghouse who gathered at the Engineers Club, New York, N. Y., Feb. 26, 1946, to honor the memory of George Westinghouse as a man and as an engineer.

The theme of the forum will be "Science and Life in the World." The three-day program will consist of conferences, addresses, and symposiums and will be attended by scientists and engineers whose activities have brought them international recognition.

Program of Forum

The opening session, titled "Science and Civilization," and presided over by Dr. Robert E. Doherty, president, Carnegie Institute of Technology, will include Dr. Isaiah Bowman, internationally prominent geographer and president of Johns Hopkins University, and George W. Merck, president, Merck & Company and special consultant to the War Department. Dr. Archibald V. Hill, foreign secretary of the Royal Society, England, and recent recipient of the Companion of Honor award, will represent England.

Four aspects of "The Future of Atomic Energy" will also be discussed the initial day of the Forum in a group headed by Dr. Karl T. Compton, president of the Massachusetts Institute of Technology. The group will delve into the biological, chemical, explosive, and power possibilities of this new form of energy.

Vannevar Bush to Speak

A Nobel Prize winner from Columbia University, Dr. I. I. Rabi, will act as chairman at a dinner that evening at which Dr. Vannevar Bush will speak on "Planning in Science." Dr. Bush is president of Carnegie Institution and Director of the Office of Scientific Research and Development.

The following morning will be given over to "Biological Sciences," headed by Dr. Hugh S. Taylor, dean of the graduate school, Princeton University. Among the participants will be Dr. Selman A. Waksman, professor of microbiology at Rutgers University. Dr. Frank B. Jewett, president of the National Academy of Sciences, will address a luncheon session on "Horizons in Communications."

A topic close to the life of Westinghouse—transportation—will be headed by Robert P. Russell, president of Standard Oil Development Company, on the afternoon of the second day. Phases to come under discussion are: Automotive, aviation, rail, marine, and transportation planning in urban areas.

The high point of the three-day program will be reached in the evening, with an address by some outstanding scientist or engineer yet to be named.

Some 800 guests who will receive formal invitations to the Forum, Mr. Price pointed out, will have an opportunity to take part in special programs at the Buhl Planetarium and Institute of Popular Science and at the Mellon Institute of Industrial Research on May 17 and 18.

Actions of the A.S.M.E. Executive Committee

At a Meeting Held at Headquarters, February 26, 1946

A meeting of the Executive Committee of the Council was held in the rooms of the Society, February 26, 1946. There were present: D. Robert Yarnall, chairman, R. F. Gagg, J. N. Landis, A. R. Stevenson, Jr., W. H. Sawyer (Finance), A. R. Mumford (Sections), K. W. Jappe, treasurer, C. E. Davies, secretary, and Ernest Hartford, executive assistant secretary.

Policy for Members in Armed Forces

It was voted to approve a statement of policy governing members of all grades and including student members qualified to transfer to junior membership who are, have been, or will be enlisted in the armed forces of the United Nations. The approved statement on "Policy for Members in Armed Forces" is published on page 381 of this issue.

Veteran's Problems and Society Guidance

With reference to a report by R. L. Sackett, assistant to the secretary, on "Veteran's Problems and Society Guidance," a vote of appreciation of the services rendered by Dean Sackett was recorded and the secretary was directed to seek methods of collecting the statistics suggested in Dean Sackett's report and to continue the present policy of aiding young men who come to Society Headquarters for advice and to refer others to A.S.M.E. Sections throughout the country.

A summary of Dean Sackett's report is published on page 378 of this issue.

Kilgore and Magnuson Bills

Noting that five A.S.T.M. Sections had given consideration to legislative policy on national research as expressed in the Kilgore and Magnuson Bills and noting further that a compromise bill had been introduced in Congress (S.1850), the Secretary was directed to publish a description of the compromise bill in Mechanical Engineering.

A factual summary and analysis of pending science legislation covered in a report "The National Science Foundation: S.1850, Final Senate Bill" prepared by Howard A. Meyerhoff, executive secretary, American Society for

ART CENTER, DETROIT, MICH., SCENE OF A.S.M.E. 1946 SEMI-ANNUAL MEETING

the Advancement of Science, and originally published in the March issue of *Science*, appears on pages 358 and 359 of this issue.

Engineering Foundation

Upon recommendation of the A.S.M.E. Research Committee, approval was voted of the proposed revision in the rules of administration of The Engineering Foundation. Under the proposed revision the Research Procedure Committee will be composed of four members from the Foundation Board (composed of one representative from each Founder Society) and the chairman of the Board, ex-officio.

Letter Symbols Standard

Upon recommendation of the Standardization Committee, it was voted to adopt the proposed American Standard for Letter Symbols for Chemical Engineering (Z10) as a standard of the Society, and to transmit it to the American Standards Association for approval as an American standard.

Group Student Conferences

Upon recommendation of the Committee on Relations With Colleges, it was decided to hold the annual Group Student Conferences, if possible, during 1946 and to provide mileage allowance already appropriated for the honorary chairmen to meet in a group even though the Group Student Conferences cannot be held.

Approval was also voted for the honorary chairman of the host school where a Group Student Conference would have been held to attend the meeting of the Regional Administrative Committee.

Organization of Engineering Profession

Upon study and discussion of the report by the Committee on Organization of the Engineering Profession of the American Institute of Electrical Engineers, it was decided to authorize the president to appoint a committee of five to study the report of the A.I.E.E. Committee of Organization of the Engineering Profession and to report the effect on the A.S.M.E. of the adoption of portions of the A.I.E.E. report.

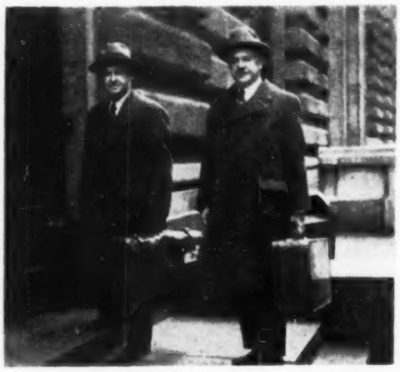
The committee was also directed to develop means for aiding the Engineers Joint Council in securing the opinions of A.S.M.E. members on forthcoming reports of the E.J.C. Committee on Organization of the Engineering Profession.

International Engineering Congress

In reply to a joint communication from the Society of Civil Engineers of France and the Union of French Engineers and Technicians the secretary was authorized to accept the invitation to organize American participation in the International Engineering Congress to be held in Paris the week of Sept. 16, 1946.

Consulting Engineers

In accordance with a communication from the Consulting Engineers Association of California opposing the encroachment of government agencies in the field of the consulting engineer as typified by the technical aid in planning improvements on the Yangtze in China provided by the Department of Interior, it was voted to deplore the increase of activity by the government in aiding work that would otherwise be performed by private consulting engineers.



D. ROBERT YARNALL, PRESIDENT, AND A. R. STEVENSON, JR., VICE-PRESIDENT, REGION III ARRIVING FOR MEETING OF THE EXECUTIVE COMMITTEE OF THE COUNCIL

John Fritz Medal Board of Award

It was voted to designate D. Robert Yarnall as A.S.M.E. representative on the John Fritz Medal Board of Award for a four-year term starting Oct. 1, 1946.

Certificate of Tribute

On the occasion of the retirement of Dr. Harrison W. Craver, director of the Engineering Societies Library since 1917, it was voted to present jointly with the other Founder Societies a certificate of tribute to Dr. Craver in recognition of his services as director of the Engineering Societies Library.

Appointments

It was voted to approve the following appointments: Research Committee (five years), William A. Newman; Wood Industries Executive Committee (five years), Charles R. Nichols; Registration Committee, junior advisers, Harold F. Brush and H. A. Kaiser; honorary chairman, California Institute of Technology, Donald E. Hudson; Standing Committee on Education and Training for the Industries, advisory members (one year), R. Burdette Dale, Arthur C. Harper, Linn Helander, Stephen D. Moxley, E. W. O'Brien, Elliott Dunlap Smith, A. R. Stevenson, Jr., Carroll L. Wilson, and W. R. Woolrich.

Thirteenth Annual Report of E.C.P.D. Available

THE thirteenth annual report of the Engineers' Council for Professional Development for the year ending Sept., 1945, released in March, 1946, reported that despite the war substantial progress has been made toward the goal of higher professional standards of education and practice and greater solidarity of the engineering profession.

The principal work of the E.C.P.D. is done through four standing committees. The Committee on Student Selection and Guidance works to find the boy in high school who would become an engineer. The Committee on Engineering Schools guides him through his college life. When he graduates, the Committee on Professional Training takes over the work of guidance for the first ten years of his junior-engineering life. Finally, the Committee on Professional Recognition aims to serve him when he becomes fully established in the engineering profession.

In order to determine the factors that bear directly on the success of individual students in engineering schools, and to relate these factors to student ability and accomplishment, the Committee of Student Selection and Guidance of the E.C.P.D. has been studying for two years, the nature of the freshman in colleges of engineering.

Typical Engineering Freshman

The typical freshman of the first few postwar years has been characterized by Dr. K. W. Vaughn of the Carnegie Foundation for the Advancement of Teaching in a report on "Measurement and Guidance in Engineering Education" which covers the examination of 4889 freshmen in 25 colleges of engineering. Dr. Vaughn says that he will be a male, 17 year of age on his last birthday and that he will come from a city of a population over 5000. He will come from a free public high school whose enrollment is 500 or over, located in the same state as the college he will attend. As for his preparation, he will have taken the college preparatory or the scientific-technical course, and will have had two years of algebra, one year of plane geometry, and one semester of solid geometry or plane trigonometry. He will have had one year of general science and one year of chemistry or physics and he may or may not have had one year of mechanical drawing.

In his report to the Council, Everett S. Lee, chairman, E.C.P.D., pointed to the special significance of the general characteristics of the engineering student and said they offer "an opportunity open to every engineer in his local community, who will give the time to work with the high schools in this territory to bring a better appreciation of the qualifications of the boy who would become an engineer."

Women Students

Although many women have come to colleges of engineering during the war years, Dr. Vaughn's report does not indicate that the trend is a strong one. The report shows that not more than four or five per cent of the freshman classes in the engineering colleges con-

sisted of women, even during the war which placed a high premium on an engineering education.

Attributes of a Profession

After considering the qualities that distinguish professional activities from the nonprofessional, the Committee on Professional Recognition listed the following attributes to aid in emphasizing the professional features of engineering: (1) A profession must satisfy an indispensable and beneficial social need. (2) Its work must require the exercise of discretion and judgment and not be subject to standardization. (3) It is a type of activity conducted upon a high intellectual plane; (*a*) its knowledge and skills are not common possessions of the general public; they are the results of tested research and experience and are acquired through a special discipline of education and practice; (*b*) engineering requires a body of distinctive knowledge (science) and art (skill). (4) It must have group consciousness for the promotion of technical knowledge and professional ideals and for rendering social services. (5) It should have legal status and must require well-formulated standards of admission.

Professional Unity

On the subject of an over-all professional society, the report says, "the committee believes in professional unity. An over-all society has great possibilities as a unifying force. During the next year we plan to make further study of this problem leading to a report and recommendation. The Engineers' Joint Council is making progress in this direction; by the end of another year its possibilities may be apparent."

Employment Conditions

The Committee on Professional Recognition took cognizance of the fact that young engineers are considering the benefits of collective bargaining, that some of them are joining trade unions while others are being forced into unions against their will. Many young men, they said, are tempted to take employment at higher salaries, which lead to blind alleys, rather than the more modest salaries which lead to promotion and finally to professional status. The Committee recommended that professional societies help their members secure adequate compensation and at the same time acquire experience which will lead them to professional success.

The E.C.P.D. is a conference organized to enhance the professional status of the engineer through the co-operative efforts of the following national organizations, concerned with the professional, technical, educational, and legislative phases of engineers' lives: American Society of Civil Engineers, American Institute of Mining and Metallurgical Engineers, The American Society of Mechanical Engineers, American Institute of Electrical Engineers, The Engineering Institute of Canada, The Society for the Promotion of Engineering Education, American Institute of Chemical Engineers, and the National Council of State Boards of Engineering Examiners.

A Copy of the Thirteenth Annual Report of the E.C.P.D. may be obtained by writing to the Engineers' Council for Professional Development, Engineering Societies Building, 29 West 39th Street, New York 18, N. Y.

Film on Involute Tooth Generation Shown to Engineers

A GROUP of technical editors and tooling engineers were guests at a lunch given by the McGraw-Hill Publishing Company, Feb. 20, 1946. Following lunch, the *American Machinist* co-operated with the Fellows Gear Shaper Company in showing two reels of films that were unusual in their clarity and instructive value. The films covered the basic principles, design, production, and testing of involute gear teeth.

Models were used to show the development of the involute tooth by the use of friction pulleys and the crossed belt and to show the sliding action taking place between the teeth as the gears revolved. The variation in this sliding action between meshing teeth, as the point of contact moved, was clearly demonstrated. It was also shown that while a change in center-to-center distance changes the line of action, the velocity ratio is not affected.

The high light of this demonstration was the use of polarized light to illustrate the formation and intensity of stresses set up in the teeth of actual gears as the line of contact advanced. The effect of improperly formed teeth and the interference between teeth was clearly demonstrated.

Production methods involved in the generation of spur and internal gears, racks and worms formed an interesting section of this film as the relationship between the cutter and the blanks during the generating action was brought out in the second reel.

A considerable portion of this reel was devoted to test methods used in checking the correctness of the teeth. Special instruments designed for checking such factors as concentricity, tooth spacing, tooth taper, and the base radius setting were demonstrated.

When electrical recorders are provided, a separate chart can be used for each of the characteristics under inspection. Any deviation from a straight line on the chart that serves as a base, or datum line, indicates the character, location and magnitude of the error.

A number of colleges have arranged to purchase copies of these films because of their educational value.

C. Paul Johnston Appointed Director of I.A.S.

CAPTAIN S. PAUL JOHNSTON, U.S.N.R. has been appointed director of the Institute of the Aeronautical Sciences. He will take his new position in April, 1946.

Captain Johnston was a cadet pilot in the U. S. Army Air Service during World War I and attended ground school at Princton University. After the war he was graduated from the Massachusetts Institute of Technology in 1921. He spent the next eight years working for the Aluminum Company of America. In 1930 he joined the editorial staff of *Aviation* and in 1936 became editor.

In 1940 he was appointed Co-ordinator of Research of the National Advisory Committee for Aeronautics, and for a time served as executive assistant with the Aircraft Activities, War Production Board. For two years he was the Washington manager of the Curtiss-Wright Corporation. He is a member of the Aeronautical Engineering Advisory Council, Princeton University.

Captain Johnston was called to active duty in June, 1944. He served with the Naval Air Transport Service, Pacific, as engineering officer, and was stationed at Honolulu. In December, 1945, he was promoted to the rank of captain, and in January, 1946, was given the Legion of Merit Award for his services.

He has written many technical articles some of which have appeared in *The Saturday Evening Post*, *The Technology Review*, and *Aviation*. He is the author of "Horizons Unlimited," "Flying Fleets," "Flying Squadron," and "Wings After War." He collaborated with Dr. Edward Warner in the Preparation of "Aviation Handbook."

A.S.M.E. Calendar

of Coming Meetings

April 1–3, 1946
A.S.M.E. Spring Meeting
Chattanooga, Tenn.

June 3–5, 1946
A.S.M.E. Aviation Division Meeting
Los Angeles, Calif.

June 12–15, 1946
A.S.M.E. Oil and Gas Power Division Meeting
Milwaukee, Wis.

June 17–20, 1946
A.S.M.E. Semi-Annual Meeting
Detroit, Mich.

June 21–22, 1946
A.S.M.E. Applied Mechanics Division Meeting
Buffalo, N. Y.

September 16–18, 1946
Industrial Instruments and Regulators Division Meeting with The Instrument Society of America
Pittsburgh, Pa.

September 30–October 2, 1946
A.S.M.E. Fall Meeting
Boston, Mass.

October 24–26, 1946
Joint A.I.M.E. Coal and A.S.M.E. Fuels Division Meeting
Philadelphia, Pa.

December 2–6, 1946
A.S.M.E. Annual Meeting
New York, N. Y.

Industrial Exposition in Cleveland, Ohio, May 23–June 2

AN INDUSTRIAL show, "Mid-America Exposition—Cleveland," will be staged in Cleveland's public auditorium and underground exposition halls, May 23 to June 2, 1946.

The exposition will be the centerpiece of Cleveland's sesquicentennial observance of 150 years of growth. It will be designed to become an annual event at which the city's industrial achievements can be displayed.

Exhibits at the exposition will show the nature of Cleveland's industrial production, its research facilities, and the degree of the craft skills and engineering resources.

Construction Industry Guide Available to Veterans

A VETERANS' handbook, "Opportunity Unlimited—A Guide for Veterans Interested in the Construction Industry," has been issued by the Committee on Opportunities for Veterans in the Construction Industry.

The booklet is addressed to engineers and architecturally minded veterans. It sets forth the opportunities for schooling, training, and immediate jobs in the construction industry.

Divided into seven parts, the book first surveys the postwar prospects of the industry, then in turn makes specific recommendations for (1) the veteran who is returning to a construction job; (2) the veteran who is interested in a construction trade; (3) the veteran who wants trade training; (4) the veteran who wants to start a business; (5) the veteran who is interested in a profession; and (6) the veteran who is an employer.

A supply of the veterans' handbooks has been received at A.S.M.E. headquarters. They are available to members upon request.

Instrumentation Conference to be Held in Pittsburgh, Pa., Sept. 16 to 20, 1946

THE first National Instrumentation Conference and Exhibit will be held in Pittsburgh, Pa., at the William Penn Hotel, Sept. 16 to 20, 1946, under the sponsorship of The Instrument Society of America.

The Industrial Instruments and Regulators Division of the A.S.M.E. plans to co-operate with The Instrument Society of America during the National Conference and Exhibit. Ed S. Smith, chairman of the Division, expects to present several A.S.M.E. papers during the conference, some of which may later be presented at a meeting of the A.S.M.E.

A feature of the technical program will be a series of short educational courses under the direction of Dr. B. R. Teare, professor in charge of electrical engineering at the Carnegie Institute of Technology, Pittsburgh, Pa.

Headquarters Helps Veterans

HOW the A.S.M.E. is aiding the veteran was explained in a report, "The Nature of the Veteran and His Problem," addressed to Secretary C. E. Davies by Dean R. L. Sackett, assistant to secretary, A.S.M.E. Dean Sackett has been interviewing two to three veterans daily, who come to the A.S.M.E. headquarters, New York, N. Y., to seek advice about the engineering profession, refresher courses of instruction, and jobs in special fields and areas.

R. L. SACKETT (RIGHT) INTERVIEWS HORACE WEST OF NEW YORK, N. Y.

A majority of the veterans, Dean Sackett said, were high-school graduates, many with no job experience and with every variety of assignment in the Armed Forces up to and including majors and several lieutenant colonels. Most of the veterans have a general idea that they want to enter the engineering profession and want advice on how to use the benefits of the G. I. Bill of Rights to the best advantage.

Referring to the individual problems encountered, Dean Sackett declared, "There is no formula or prescription which will solve all or even two of the problems presented. They are definitely individual. Each needs a sympathetic experienced counselor who can help the man to probe himself, diagnose his strength and his weakness, and give him a steer toward that fundamental self-analysis and that understanding of what engineering takes to succeed."

When the veteran was a junior or member with industrial engineering experience, the name of the secretary of the proper A.S.M.E. section was given to the visitor. Dean Sackett stated, "The sections were informed of the plan of referring veterans to them and some sections have set up special committees to deal with them."

As a result of his experience Dean Sackett feels that there is a general preference for mechanical engineering among veterans who are thinking of an engineering career. He said that present enrollments in that field seem to lead all others.

Dean Sackett believes that the majority of the veterans aided will become student members and that reasonable aid on the part of Student Branches will lead to an increase in junior membership.

At any rate, the A.S.M.E. is making many friends.

Safety Conference to Be Held in New York, N.Y. April 9 to 12

THE 16th annual Safety Conference and Exposition, sponsored by the Greater New York Safety Council, will be held in the Hotel Pennsylvania, New York, N. Y., April 9 to 12, 1946.

Forty-five sessions are planned during which every field of safety, including industrial, traffic, vehicle, and commercial will be discussed. Over 100 exhibit booths will display the largest collection of safety equipment ever shown in New York.

D. W. Atwater, past-president of the Illuminating Engineering Society, will be chairman of the demonstrations session. During this session, scheduled for April 11, 1946, demonstrations will be given of special lighting applications in the city transit system for passenger safety, tank ventilation techniques, and a new alcholometer developed in the laboratory of applied physiology, Yale University, New Haven, Conn.

O.P.R.D. Moves to Commerce Department

THE OFFICE of Production Research and Development was transferred by executive order from the Civilian Production Administration to the Department of Commerce, where it will be known as the Production Research and Development Division of the Office of Declassification and Technical Services.

John C. Green, former chief engineer of the Inventors' Council, is director of the Office of Declassification and Technical Services.

The new address of the former O.P.R.D. is 1837 Commerce Building, Washington, D. C.

50,000 Attend National Metals Congress and Exposition

FIFTY-THOUSAND metallurgists, engineers, and manufacturers crowded hotels and the Cleveland Public Auditorium to attend the 27th National Metals Congress and Exposition, sponsored by the American Society for Metals, held in Cleveland, Ohio, Feb. 4 to 8, 1946. So much interest was displayed in the 450 exhibits showing the metals developments of the past few years, that the American Society for Metals is planning to hold a similar congress and exposition late in 1946 in some eastern city.

Most of the exhibitors had something new and different to show. While the electronics exhibits attracted much attention, there was intense interest in other war developments

from which government restrictions had been removed.

One of the most interesting exhibits was a building within a building. A 40 × 60-foot Quonset building was erected inside the Lower Exhibit Hall to house and feature an exhibit of high tensile steels. The "Quonset 40" is one of the round-roofed, metal structures of war fame produced by the Stran-Steel Division of Great Lakes Steel Corporation. The display focused attention on the metal industry's contribution to building construction at a time when the national shortage of ordinary building materials is acute.

At the annual dinner of the American Society for Metals held Feb. 7, 1946, the Gold Medal of the society was awarded to Earl C. Smith, chief metallurgist, Republic Steel Corporation, in recognition of his efforts in developing special metals. The Medal for the Advancement of Research was awarded to Gerard Swope, honorary president, General Electric Company. The 1945 Sauveur Achievement Award was presented to Robert S. Archer, metallurgist, Climax Molybdenum Company, New York, N. Y.

In recognition of their paper, "Tempering of High-Carbon Steel," the 1945 Henry Marion Howe Medal was awarded to Dara P. Antia, Indian Aluminum Company, Calcutta, India; Stewart G. Fletcher, research metallurgist, Latrobe Electric Steel Company, Latrobe, Pa.; and Morris Cohen, associate professor of metallurgy, Massachusetts Institute of Technology, Cambridge, Mass.

Large Funds Available for Bituminous-Coal Research

DIRECTORS of Bituminous-Coal Research Incorporated, national research agency for the bituminous-coal industry, approved a budget for 1946 that calls for investing $401,000 in more than 40 research projects intended to improve utilization of solid fuels by railroads, industry, and domestic consumers.

Battelle Memorial Institute

More than one half of the current B.C.R. budget covers projects under way and to be started this year at Battelle Memorial Institute, Columbus, Ohio. Twenty-six projects had been allocated to Battelle, including fully automatic stokers, smokeless stoves, furnaces, ranges and water heaters, group heating, and chimney design and construction, all in the residential-heating field; railroad coal uses, such as air supply, overfire steam-air jets, effect of fuel on locomotive performance, and handling railroad coal; industrial steam and nonsteam uses, gasification of coal, and coal drying and preparation.

The B.C.R. is a major contributor to the Coal Research Laboratory of Carnegie Institute of Technology, Pittsburgh, Pa., where basic research is under way on combustion and gasification processes, heat transfer into coal during carbonization and combustion, coke quality, and the production of chemicals by hydrogenating coal.

Residential uses of bituminous coal came in for the greatest share of the B.C.R. budget. A sum of $142,750 has been set aside for domestic projects, including a comprehensive study of improved designs for houses heated with bituminous coal. Railroad locomotives were next in line, $45,500; and the third largest appropriation was for mining, preparation, transportation and handling of coal, $37,000. The remainder of the new budget has been allocated to gasification, industrial steam and nonsteam uses, carbonization, chemicals from coal, development work leading to commercialization of new coal-burning equipment; technical information service, including "Bituminous Coal Research" bulletin; preliminary studies of proposed projects, administration, public relations, and sales promotion.

Locomotive Development Committee

B.C.R.'s Locomotive Development Committee has announced projects under way or authorized at Battelle Memorial Institute, Johns Hopkins University, Southern Research Institute, the Institute of Gas Technology, Purdue University, and the Alco Products Division of American Locomotive Company. None of these, however, is included in the general budget of $401,000 of Bituminous Coal Research, Inc. The budget for the locomotive-development work, the goal of which is a coal-fired gas turbine to provide motive power for railroad engines, represents a separate allocation of funds. Locomotive-development projects are administered from Baltimore, Md., by John I. Yellott, member A.S.M.E., director of research, Locomotive Development Committee.

Locomotive Development Committee

Principal office of Bituminous-Coal Research, Incorporated, is located in Pittsburgh, Pa. Administrative work is directed by Harold J. Rose, vice-president and director of research. He is assisted by Elmer R. Kaiser, Junior member A.S.M.E., assistant director of research, and T. A. Day, special representative. Howard N. Eavenson of Pittsburgh is president of B.C.R. A Washington office is staffed by C. A. Reed, member A.S.M.E., secretary; M. L. Garvey, treasurer; and J. F. Hanley, assistant secretary-treasurer.

Handbook on Welding Inspection Offered by A.W.S.

THE American Welding Society has announced the publication of "Inspection Handbook for Manual Metal-Arc Welding." This handbook has 156 pages and is a complete and authoritative manual on welding inspection.

It covers the requirements and duties of a welding inspector, methods of testing welds, and contains a comprehensive description of weld inspection by visual, magnetic-particle, and radiographic methods. One section of the handbook discusses the principal types of weld defects and indicates how they may be detected and corrected. The book is written in simple language and is intended to serve as a reliable source of information on any welding inspection problem. Copies may be obtained from the American Welding Society, 33 West 39th Street, New York 18, N. Y., at $1.50 per copy.

Honors and Awards

THE Board of Honors and Awards of The American Society of Mechanical Engineers is developing information leading to the awarding of various honors and awards including Honorary Membership. It is pointed out specifically that a nomination for Honorary Membership may be made by twenty-five members of the Society who shall state in writing the grounds upon which the nomination is made.

Information regarding candidates for any of the medals of the Society or for Honorary Membership should be in the hands of the Committee not later than April 19. It should be addressed to the Board of Honors and Awards, care of the Secretary's Office, A.S.M.E., 29 West 39th Street, New York 18, N. Y.

Detailed information regarding honors and awards of the Society will be found in the Society Records—Part I of the Transactions of the A.S.M.E. for February, 1946, a copy of which may be obtained on request.

Gerard Swope Honored by A.S.M.

GERARD SWOPE, honorary president, General Electric Company, Schenectady, N. Y., and recipient of numerous awards for his achievements in the field of human relations in industry, was honored Thursday evening, Feb. 7, 1946, by the American Society for Metals at the annual meeting held in Cleveland, Ohio. Mr. Swope was presented the A.S.M. Medal for the Advancement of Research for his accomplishments in promoting research for the increased use of metals.

The presentation was made by Kent R. Van Horn, president of the American Society for Metals, and manager of the research division of the Aluminum Company of America, Cleveland, Ohio.

The citation which accompanied the award was presented to Mr. Swope in an illuminated scroll and emphasized the encouragement given by the industrialist to the furtherance of research which resulted in many contributions to the knowledge of metallurgy during his long term of office as president of General Electric Company. "Prominent among these developments," read the citation, "are cemented carbides; carbon-free alloys comparable in hardness to hard steels; magnetic materials, soft and hard, metallic and nonmetallic; high-temperature alloys; precision casting processes; hydrogen brazing; resistance-welding electrodes; and special alloys for mercury turbines."

Special Course in Diesel Engineering Offered

A SHORT course for college teachers of Diesel engineering covering recent developments and reviewing principles underlying Diesel-engine design, manufacture, and performance will be given by The Pennsylvania State College, State College, Pa., June 24 to July 6, 1946. Attendance will be limited to forty college teachers.

A copy of a brochure outlining the program and giving other information may be obtained by writing to The Pennsylvania State College, School of Engineering, State College, Pa.

Dr. Harrison W. Craver Appointed Consulting Librarian

DR. HARRISON W. CRAVER, director of the Engineering Societies Library, Engineering Societies Building, New York, N. Y., has been appointed consulting librarian of the Library, effective Feb. 1, 1946. The appointment was made to meet the desire of Dr. Craver for greater leisure and more freedom from the pressing duties of Library administration while not depriving the Library of his valuable experience and knowledge. Ralph H. Phelps, assistant to the director, was appointed acting director of the Library, effective Feb. 1, 1946.

Dr. Craver, who is a native of Illinois and a graduate of Rose Polytechnic Institute where he studied chemistry and from which he received the honorary degree of Doctor of Science in 1933, came to the Engineering Societies Library in 1917 from the Carnegie Library of Pittsburgh, Pa., where he served as technical librarian. During the past 29 years of Dr. Craver's active leadership, the Library has undergone great development and has extended its facilities for reference and its opportunities for research to a great number of persons throughout the United States and Canada.

Developed Library Services

Largely instrumental in establishing the "Service Bureau" which provides references and abstracts of articles, and the "Photostat Service" which provides photostatic copies of articles or pages in any volume in the Library, Dr. Craver was also responsible for changing the fundamental procedure of the Engineering Societies Library to a system by which any member of the four Founder Societies, no matter where situated in the United States or Canada, can obtain books by mail at a nominal charge. By this change he made the Library available to all members of the Founder Societies and not exclusively to those in the New York district.

Dr. Craver was instrumental in persuading the Founder Societies to merge all of the materials of their individual libraries into a single collection within the Engineering Societies Library. For many years after he had accepted the directorship of the Library he devoted a large portion of his energies to completing a card catalog of all of the material housed in the Library. He has also served as chairman of the Engineering Societies Monographs series.

Dr. Craver is a member of numerous scientific, historical, and library societies and clubs. His wide knowledge of scientific, engineering, and general literature and his facility in foreign languages, coupled with a librarian's "sixth sense" in ferreting out references on an infinite variety of subjects, have been important factors in his successful administration of the library.

RALPH H. PHELPS, NEW ACTING DIRECTOR

New Acting Director

Mr. Phelps comes to his new duties as acting director of the Engineering Societies Library with wide experience as a technology librarian. Majoring in chemistry, he was graduated from Monmouth College in 1928. He served in the technology department of the Carnegie Library of Pittsburgh, Pa., after graduation, while continuing his studies in library science at the Carnegie Institute of Technology. In 1939 he became technology librarian of the Birmingham Public Library, Birmingham, Ala. He left that position to become librarian of the War Metallurgy Committee of the National Academy of Sciences and the National Research Council. In 1945 he came to the Engineering Societies Library as assistant to Dr. Craver.

Mr. Phelps has compiled bibliographies on sponge iron, iron wire, and steel. He also edited and arranged the "Trade-Names Index" published in 1941 by the Special Libraries Association.

Mr. Phelps is a member of the American Chemical Society, the American Library Association, and the Special Libraries Association.

Government Favors A.S.A. Procedures in Industrial Standardization

A NEW concept in the relationship between business and industry was suggested by Henry Wallace, Secretary of Commerce, in his letter to Charles E. Wilson, chairman, Policy Committee on Standards, dated Feb. 28, 1946, in which he accepted the principal recommendations of a national committee of 50 industrial and commercial executives, to return to private enterprise the important function of determining industrial and consumer standards. In effect, Mr. Wallace's statement of policy promises to reverse the wartime trend that was placing the government in a dominant role in the field of industrial standardization.

Because of the ever-increasing importance of industrial and consumer-goods standards on the national economy and the need of an orderly procedure for developing them, the Secretary of Commerce in Jan., 1945, invited representative industrial leaders to attend a "Conference on Standardization." Out of this conference came the Policy Committee on Standards, under the chairmanship of Charles E. Wilson, president, General Electric Company. In its report of June 1, 1945, the Policy Committee expressed the belief that standards activities which involved negotiation, opinion, judgment, and compromise should be developed through individual and joint efforts of technical, manufacturing, merchandising, and consumer groups, and that such efforts should be co-ordinated and promoted by a disinterested private agency organized to function in the broad public interest. This function, they reported, could most logically be fulfilled by the American Standards Association.

The Policy Committee also recommended that the Division of Simplified Practices and the Division of Trade Standards, at the present time a budgetary part of the National Bureau of Standards, be transferred from the Bureau of Standards to a more suitable status in the Department of Commerce.

In his letter Mr. Wallace reviewed his plans to reorganize his department in accordance with the recommendations of the Policy Committee, and stated that as soon as the American Standards Association strengthens its organization "so that it can perform trade standard services to the satisfaction of all groups with an interest in standards, the Department is prepared to encourage the use of facilities of the American Standards Association for the initiation, development, and publication of standards." He expressed the hope that American industry would support and take full advantage of the facilities of the A.S.A.

In the light of its new responsibilities, Henry B. Bryans, president, A.S.A., announced a number of steps taken to strengthen the A.S.A. along the lines recommended by the Policy Committee. Through a change in its constitution, the A.S.A. has broadened the scope of its work so that it may deal with any standards or standardization projects deserving national recognition, whether in the field of engineering, consumer goods, or in other fields. By adding a consumer leader, a retailer, and a publisher of a national magazine, the

A.S.A. is rounding out its board of directors. Consumer groups and other groups concerned are represented on the main A.S.A. committee on consumer standards and methods of work are being streamlined.

These steps were outlined in a letter to Mr. Wallace dated March 8, 1946, in which Mr. Bryans informed the Secretary of Commerce and the Policy Committee that the A.S.A. will be able to render all required services and that it accepts the responsibility offered.

In the correspondence between the Secretary of Commerce, the Policy Committee on Standards, and the A.S.A., which is in essence an exchange of statements of policy, not only is the trend toward voluntary industrial self-regulation evident but also the direction it will take. The three organizations are in agreement that high standards of living for our future can only be the result of ability of our industrial processes to create goods through mass-production methods and that these methods will best evolve through industrial standards which are established through voluntary effort of all concerned.

1945 Lamme Medal Award to David C. Prince

THE 1945 Lamme Medal of the American Institute of Electrical Engineers has been awarded to David C. Prince, member A.S.M.E. vice-president, general engineering and consulting laboratory, General Electric Company, Schenectady, N. Y., "for his distinguished work in the development of high voltage switching equipment and electronic converters."

The medal will be presented at the summer convention of the American Institute of Electrical Engineers to be held in Detroit, June 24 to 28, 1946.

The Lamme Medal was established through a bequest of Benjamin Garver Lamme, who was chief engineer of the Westinghouse Electric Corporation from 1903 to his death in 1924. Beginning with 1928, the medal has been awarded annually for high achievements in the development of electric apparatus or machinery.

Policy for Members in Armed Forces

THE policy of the Society governing its members of all grades and also its student members qualified to transfer to junior membership, who are, have been, or will be enlisted in the Armed Services of the United Nations shall be as follows. This policy will not apply to those members who remain in the Armed Services for a career.

MEMBERS

Dues Suspension—Inactive

Members (other than student members) of all grades who signify that they are, have been, or will be enlisted in the Armed Services of the United Nations are entitled to cancellation of dues for the period they are in the Services and will be carried on an inactive membership roster, but during this period they will not be entitled to receive the Society's publications. They will retain their original date of election, and their names will be published in the Society's membership list.

Application for Active Membership

Members in the Armed Services of the United Nations will be given six months after being released from the Services to apply for active membership or they may apply for active membership while still in the Services, and after payment of prorated dues, they will receive the Society's publications.

Dropped Members

Members who unknown to the Society are, have been, or will be enlisted in the Armed Services of the United Nations and have been dropped from membership for nonpayment of dues are entitled to have such dropped action rescinded and they will regain their dates of election which they had at the time of joining the Armed Services, with dues canceled during such period of service.

Dues Exemption

Although Members in the Armed Services will have their dues canceled, upon request, for the years they have been in the Services, they will not have those canceled years included in the years used for calculating the dues-exemption period.

Transferring of Junior Member to Member Grade Without Fee

Junior members who are, have been, or will be enlisted in the Armed Services shall be entitled to be credited with such years of service toward the period of time (five years) which would allow them to transfer from junior to full-grade member without payment of transfer fee.

STUDENT MEMBERS

Student Members Qualified to Transfer to Junior Member Grade

Student members qualified to transfer to junior member grade who are, have been, or will be enlisted in the Armed Services of the United Nations, may have their status of transfer held in abeyance during such service. Student members qualified to transfer to junior member grade must take up and complete their transfer to junior member by payment of dues within twelve months after being released from the Services, if the transfer fee is to be waived. Student members qualified to transfer to junior member grade, joining the Armed Services, who make a quarter year's payment of dues will receive a card indicating they are members of The American Society of Mechanical Engineers and hold junior membership status. Student members who are qualified to transfer to junior member grade and who allow more than twelve months to lapse after being released from the Services must pay the initiation fee and be passed upon by the Committee on Admissions.

Date of Election

Student members who are qualified to transfer to junior member grade and who join the Armed Services with trasnfer held in abeyance, will receive as their date of election the date they begin payment of their first year's junior membership dues, within the twelve months' period after being released from the Services, unless they choose to take up their transfer to junior member grade by payment of dues prior to their release from the Services. The first year's membership will end September 30th of the calendar year following the calendar year that the first payment of dues has been received.

Elections Declared Void

Student members who were or are qualified to transfer to junior member grade and who join the Armed Services but fail to notify the Society of that fact may have their elections declared void in conformity with the Society's Constitution, By-Laws, and Rules. Upon receipt later from such student members whose elections were declared void that they have been in the Armed Services, such voided actions will be canceled and their elections will be treated in the same manner as the students who notify the Society of enlistment in the Armed Services.

South Fosters Safety Engineering

ENGINEERED safety in the South was the theme of the report presented at the National Safety Council's three-day meeting of college and university representatives, Feb. 5–7, 1946, by Blake R. Van Leer, president, and William N. Cox, Jr., professor of safety engineering, Georgia School of Technology. Summarizing the activities of the new department of safety engineering, the first one to be established in a college in the United States, the report points out how in six months the department evolved a program for the development of engineers, technicians, and other trained personnel necessary to the welfare and safety of the postwar industrialized South.

Representatives of New York University, Illinois Institute of Technology, and the University of California who attended the meeting, received the report favorably and planned to incorporate some of the Georgia School of Technology plan into their own safety-engineering departments. All of these departments were established on or after July 1, 1945, through the sponsorship and financial aid of the National Safety Council.

The Georgia Tech plan covers both the academic and industrial fields of activity. At the school, activity has been planned or already started in the Graduate Division, Undergraduate Divisions, Evening School of Applied Science, and the Extension School. In addition, a campus safety program was established for the benefit of faculty, students, and employees. Under the direction of Mrs. J. H. Crosland, librarian of Georgia Tech, there has been built up a fairly complete collection of pamphlets, periodicals, and books on safety subjects. In its program of aid to the industries of Georgia and the Southeast, the department has offered to aid them through safety surveys, conferences, and lectures.

Clyde A. McKeeman Joins A.S.H.V.E. Staff

THE American Society of Heating and Ventilating Engineers, New York, N. Y., announced the appointment of Clyde A. McKeeman, as assistant to the president of the Society. Mr. McKeeman will represent the Society in securing the interest and participation of industry in the Society's research activities. Mr. McKeeman was graduated from the University of Maine in 1923, with a degree of B.S. in mechanical engineering. He received his M.S. degree in 1931 from Harvard University School of Engineering.

Lubricants Concern of A.S.M.E. Textile Division

IN order to clear away some of the confusion that is now reported to exist in the textile industry because of the large number of trade names and unrelated code numbers covering specifications of lubricating oils offered by the different lubricant manufacturers, the Textile Lubrication Committee of the A.S.M.E. Textile Division sponsored a conference on textile lubricants which was held at the Associated Factory Mutual Fire Insurance Companies, 10 High St., Boston, Mass., Sept. 21 and 22, 1945.

Report Available

The official report of this conference attended by 25 textile and lubricating engineers has been published in mimeograph form and is available for $1 per copy by writing to the secretary of the Textile Division, W. A. Smith, Jr., 210 South St., Boston 11, Mass.

With reference to the problem of lubricants in the textile industry, C. D. Brown, chairman, A.S.M.E. Textile Division said, "In the textile industry the situation is particularly bad because each lubricant manufacturer has his own trade name and code number, so that the textile industry is at the mercy of these manufacturers and must rely upon their judgment in recommending a lubricant without regard to specification."

"The textile-machinery manufacturers, the textile mills, and a few of the lubricant manufacturers are very much concerned because of this practice," he continued, "and would like to establish some form of classification or standard so that lubricants could be furnished from any source of supply."

Future Program

The work of the Textile Lubrication Committee has been aimed at convincing the lubricant manufacturers that they should co-operate with the A.S.M.E. Textile Division and establish reasonable standards for lubricants used in the industry. Mr. Brown feels that this problem may require a field-study embracing the entire textile industry and may include a study of the proper procedures for lubricating specific machines as well as the recommendation of a standard for lubricants.

The Textile Lubrication Committee of the A.S.M.E. Textile Divisionmet in Boston, Mass., March 15, 1946, to continue the work of the lubrication conference. The committee plans to present a paper for discussion at the A.S.M.E. Fall Meeting in Boston, Mass., Sept. 30 to Oct. 2, 1946.

Newark College of Engineering to Expand Facilities

THE Newark College of Engineering, Newark, N. J., will embark on an expansion program which will increase normal day enrollment to 1000 students and will add three new units to the College facilities, including a 20-story "educational skyscraper." The program will cost $2,700,000.

Unit No. 1 will house greatly enlarged laboratory facilities and new equipment. Located on the main floor will be the heavy machinery such as generators, airplane engines, and motors. The remaining floors will be assigned to physics, chemistry, electrical, and electronics equipment.

Unit No. 2 will include the administrative offices, lecture halls, library, museum, cafeteria, swimming pool, auditorium, and gymnasium.

Unit No. 3 will contain classrooms, student activities areas, clubrooms for professional engineering societies and college organizations, faculty and student lounges and a coffee shop. A glass solarium will top the structure and may eventually be used in connection with radar experimentation.

A.I.E.E. Nominates Officers for 1946–1947

THE AMERICAN Institute of Electrical Engineers at a meeting of its nominating committee designated J. Elmer Housley, district power manager, Aluminum Company of America, Alcoa, Tenn., as its nominee for president of the Institute for the term beginning Aug. 1, 1946.

The following were nominated vice-presidents: Ernest W. Davis, chief electrical engineer, Simplex Wire & Cable Company, Cambridge, Mass.; O. E. Buckley, president, Bell Telephone Laboratories, Incorporated, New York, N. Y.; T. G. LeClair, supervising development engineer, Commonwealth Edison Company, Chicago, Ill.; R. F. Danner, general superintendent, Oklahoma Gas & Electric Company, Oklahoma City, Okla.; Charles Foster Terrel, vice-president, Puget Sound Power and Light Company, Seattle, Wash.; J. F. Fairman, vice-president, Consolidated Edison Company of New York, Inc., New York, N. Y.; Raymond T. Henry, chief electrical engineer, Buffalo, Niagara & Eastern Power Corporation, Buffalo, N. Y.; and E. P. Yerkes, Bell Telephone Company of Pennsylvania, Philadelphia, Pa.

W. I. Slichter, fellow A.S.M.E., professor emeritus of electrical engineering, Columbia University, New York, N. Y., was nominated for treasurer.

A.W.S. Adams Lectures Now Available in Reprint Form

THE Adams lectures presented during the 1944 and 1945 annual meetings of the American Welding Society are available in pamphlet-form reprints. The Adams lecture is given each year by a prominent scientist or engineer on some new and distinctive development in the field of welding.

Dr. August B. Kinzel was the Adams lecturer for 1944. His subject, "Solid Phase Welding," is an analysis of the principles and theory of pressure welding and solid-phase bonding. He discussed the fundamental mechanism of bonding, the theories of metallic cohesion, atomic bonding, and film diffusion. Dr. Kinzel described many examples of application of these principles to the welding of steel; to the welding of nonferrous materials such as copper, brass, and silver; and to the welding of two dissimilar metals or alloys.

As Adams lecturer for 1945, Dr. Samuel L. Hoyt spoke on "Selection of Steel for Welding." He explained why steel selected for welding should be chosen for "welding quality," which includes not only weldability but also the qualities needed for service after fabrication.

Dr. Hoyt also suggested that tests and specifications for steel which are satisfactory for riveted construction may not be entirely satisfactory in selecting steel for welded construction, and that "cohesive strength" and notch brittleness are closely related.

Copies of these lectures, bound in paper, sell for $0.50 per copy, and may be obtained from the American Welding Society, 33 West 39th Street, New York 18, N. Y.

Metropolitan Section Spring Round-Up

THE Metropolitan Section is planning to hold its Annual Spring Round-Up on *May 1, 1946*. It promises to be the best ever conducted and will be held in the spacious and luxurious Grand Ballroom of the Waldorf-Astoria Hotel, New York, N. Y. As in the past, a gala array of star performers have been engaged to provide the entertainment. The professional talent for the show will be supplied by Carlton Hub, famous entrepreneur of Actors Equity. Chairman for the affair is the popular and very capable H. A. Johnson.

Various other Committees have been appointed and each reports enthusiastically that everything seems to be pointing to make the Spring Round-Up the social high light of the year. Tickets will be available at $10 per person and may be secured at A.S.M.E. Headquarters, 29 West 39th Street, New York 18, N. Y.

Locomotives of the Future Discussed by Four Speakers At Washington, D. C., Section

FOUR engineers closely associated with the design of steam, electric, Diesel, and gas-turbine locomotives spoke on "Locomotives of the Future" before 400 members and guests of the Washington, D. C., Section of the A.S.M.E. at a regular meeting held Feb. 14, 1946, in the U. S. Department of Commerce Building Auditorium, Washington, D. C.

Improvements expected in the steam locomotive were outlined by Charles Heilig, engineering department, The Baldwin Locomotive Works. Design trends in the electric locomotive were sketched by W. A. Brecht, manager of transportation engineering, Westinghouse Electric Corporation. R. Tom Sawyer of The American Locomotive Works spoke about the future of the Diesel locomotive and J. T. Rettaliata, consulting engineer, Allis-Chalmers Company, spoke of the impelling advantages of the application of the gas turbine to locomotive design.

Steam Locomotives

"The steam locomotive of the future," said Mr. Heilig, "is not going to take a sudden dramatic jump into higher thermal efficiencies or 100 per cent availability, but the steady improvement of the years will continue." He said that the future steam locomotive "should include those details now incorporated in present-day designs, such as locomotive-bed castings, roller bearings throughout, and feedwater heater."

Among the improvements that may be expected, Mr. Heilig listed (1) poppet valves, which will offer an opportunity to use steam more efficiently at high speeds; (2) fireboxes arranged to burn pulverized coal, a change which will offer the possibility of better combustion efficiencies; (3) higher steam pressures and temperatures, which will provide greater capacity for the same weight; and (4) welded boilers, which promise lower maintenance costs, increased availability, and decreased weight.

Electric Locomotives

"The electric locomotive," said Mr. Brecht, "is the best known tool for securing the large concentrations of power required to haul heavier loads at higher speeds. The trend in electric-power costs is downward, while coal and oil prices are rising and oil is in diminishing supply. These trends in power costs together with the demand for larger motive-power units will extend the electrification of American railroads in the future."

Under present conditions and at present electric-power costs many miles of American main lines could profitably be electrified, he said. Comparing the size of the electric locomotive with that of the Diesel, he said that "a 20,000-hp electric locomotive can be produced which is no longer than a modern 6000-hp Diesel locomotive."

Commenting on the electric locomotive, Mr. Sawyer said that while this type of locomotive has made an excellent record in congested areas, there has been practically no extensive electrification which has not been backed up by the steam or Diesel engine.

Diesel Locomotives

Mr. Sawyer predicted a bright future for the Diesel locomotive. He said that 10 per cent of the switching and road locomotives today are Diesel-powered and that in the next ten years this percentage should increase to twenty or even forty per cent.

"Each type of motive power," he said, "will find its own place. No one is going to push one type more than another unless it pays to do so, and the railroads will put that type of locomotive in service which gives them the greatest return on investment. This means that the railroads will use Diesels for all switching operations, with few exceptions."

Because local conditions largely determine the most economical type of power, he said, the Diesel locomotive would have to compete in main-line service with the steam locomotive and eventually with gas-turbine power.

Gas-Turbine Locomotives

The advantages of the gas turbine which urge its application as a motive power for locomotives were discussed by Mr. Rettaliata. He said that because the gas turbine requires no water for its operation, its use will eliminate the necessity of water treatment, as well as frequent inspections, cleanings, and repairs to boilers, which plague steam-locomotive maintenance.

Since large amounts of excess air are used in gas-turbine operation, clear stacks completely free from smoke at all operating loads can be a reality, and he said that the purely rotary motion of the gas turbine would result in a minimum of maintenance and vibration.

"When dynamic braking is considered," Mr. Rettaliata said, "the application of the gas turbine to locomotives is exemplary. By operating the traction motors as generators, the motorized main generators may be loaded by driving the gas turbine and its associated compressor. The energy required during compression can be dissipated by discharging the compressed air to the atmosphere. With such an arrangement, the electric-resistor grids normally required for dynamic braking are eliminated."

He said that gas-turbine locomotives make thermal efficiencies of the order of 20 to 25 per cent feasible and that when consideration is given to the low-grade fuel oils which can be used, these efficiencies on a fuel-cost basis make the gas-turbine drive relatively attractive.

Quality-Control Engineers Organize National Society

REPRESENTATIVES of twenty quality-control societies from all over the United States met Saturday, Feb. 16, 1946, at the Edison Electric Institute to form a new national organization, the American Society for Quality Control. This society is a spontaneous expression of some 5000 industrial quality-control operators who, during the war, were responsible for saving millions of dollars in industrial plants.

Quality-control engineers are the process trouble-shooters of industry. Their job is to find why the products which should flow into consumer channels go into the scrap barrel. Their job is to point out faults in production and to show management how to produce a higher percentage of acceptable goods. Quality control is like a burglar alarm on the production line, quickly telling the production supervisor when something has gone wrong and when he is producing unsatisfactory material.

For many years the separation of good products from bad was done at the end of the line. This was, of course, necessary, but it was locking the stable door after the industrial horse was stolen. Today, stimulated by the war, management enters the highly competitive postwar period with the new tool—quality control—which picks up defective material as it is produced. In this way industry attacks, directly at the source, the problems of scrap, salvage, assembly failure, and customer complaint, which are the real thieves of industrial profits.

The growth of industrial quality control was apparent many years before Pearl Harbor, but with the mushrooming production of war material, Army and Navy agencies were quick to realize what quality control could do for the war effort by minimizing the waste of critical materials. Through the Engineering, Science, and Management War Training program, the government sponsored courses in quality control at technical schools from coast to coast in order to provide the required personnel. As people were trained and absorbed into quality-control work, many regional societies sprang up. A national organization was the natural result of growth.

The officers of the new society are: president, George D. Edwards, Bell Telephone Laboratories, New York, N. Y.; vice-president, Andrew I. Peterson, member A.S.M.E., RCA Victor Division, Radio Corporation of America, Harrison, N. J.; executive-secretary, Ralph E. Wareham, National Photocolor Corporation, New York, N. Y.; and treasurer, Alfred L. Davis, Rochester Institute of Technology, Rochester, N. Y.

The following societies were represented: Boston, Buffalo, California, Chicago, Delaware, Detroit, Georgia, Illinois, Indiana, Northeastern Indiana, Iowa, Milwaukee, Nebraska, Newark, Northwestern, Ohio, Philadelphia, Pittsburgh, Rochester, and Syracuse.

Latin-American Awards Established by A.S.C.E.

TO stimulate Latin-American interest in the American Society of Civil Engineers and to advance good-neighbor relations, L. F. Harza, member A.S.M.E., Chicago consulting engineer, turned over to the A.S.C.E. a sum of $1600 to be used for paying annually the entrance fees for junior membership, first year's dues, and the cost of Society badges for at least eight qualified Latin-American university civil-engineering graduates. Not more than two graduates are to be selected from any one country in one year.

Selection of candidates will be made for outstanding scholarship, personality, and interest in Pan-American affairs. To receive considerations by the A.S.C.E., each candidate must be nominated by his university and is required to submit application for junior membership and meet all requirements for such membership. Mr. Harza's fund will be used to pay the entrance fees, the first year's dues, and the cost of a society badge for the selected candidates.

Mr. Harza served as consulting engineer for the Uruguayan government on its Rio Negro hydroelectric project.

Safety Rules Suggested by Plainfield Section

A RESOLUTION offering two suggestions to the New Jersey State Commissioner of Motor Vehicles was adopted by the A.S.M.E. Plainfield Section at the executive meeting of the Section held Feb. 6, 1946.

Aimed at safer driving, the resolution suggested (1) that a handbill containing the main traffic rules issued by the state be given to each operator when annual licenses are issued, and (2) that all buses be required to stop on the far side of an intersection.

With regard to bus stops it was claimed that such a rule would allow an unobstructed flow of traffic and that passengers alighting from the bus would go the rear instead of attempting to cross in front of the bus.

John D. Potter, chairman of the Plainfield Section, in calling the resolution to the attention of Headquarters, pointed out one way in which other A.S.M.E. sections can be of service to their communities.

R.W.M.A. Elects 1946 Officers

AT THE regular meeting of the Resistance Welder Manufacturers' Association, which was held in Detroit, Mich., on Jan. 24, 1946, the following officers were elected to serve during 1946: president, H. B. Warren, executive vice-president, Thomson-Gibb Electric Welding Company, Lynn, Mass.; vice-president, G. N. Sieger, president and general manager S-M-S Corporation, Detroit, Mich.; executive secretary, George A. Fernley, Philadelphia, Pa.; secretary-treasurer, H. R. Rinehart, Philadelphia, Pa.

Time-Study and Methods Conference—New York, N. Y., April 26–27

THE Management Division of The American Society of Mechanical Engineers and the Society for the Advancement of Management will sponsor annually a conference in New York, N. Y., devoted to the techniques of industrial engineering. The first jointly sponsored conference will be the Time-Study and Methods Conference to be held at Hotel Pennsylvania, New York, N. Y., April 26 and 27, 1946.

Technical Sessions

This conference will be divided into four sessions during which 12 papers covering job-evaluation, motion-study, wage incentives, training of time-study personnel, and office methods will be presented. The tone of the conference will be factual and specific. Every effort is being made to discourage discussions on philosophy and policy and to steer discussions to actual problems encountered in the practice of the techniques of industrial engineering in industry today.

The program is designed to attract practicing industrial engineers, plant managers, production superintendents, and industrial and labor-relations managers.

Dr. Herbert Spencer to Speak

Dr. Herbert Spencer, president, Bucknell University, will address the conference on "How to Avoid Mistakes in Time-Study and Incentives Which Lead to Arbitration" during the luncheon, Friday, April 26, 1946.

The conference committee is under the chairmanship of J. E. Louden, S.A.M. J. M. Juran, member A.S.M.E., is vice-chairman.

Unification of Engineering Standards Conference Report Available

THE official report of the Conference of the Unification of Engineering Standards, which was held under the auspices of the Combined Production and Resources Board at Ottawa, Can., Sept. 24 to Oct. 6, 1945, has been published and copies may be obtained from Superintendent of Documents, U. S. Government Printing Office, Washington, D. C., at $0.20 per copy.

The Conference discussed such subjects as screw threads, pipe threads, limits and fits, drawing practice, and metrology, in an effort to remove the fundamental differences between British and American screw-thread forms, which caused tremendous production and supply difficulties during the war.

One of the outstanding accomplishments of the Conference was the proposal of a basic thread form which could be found acceptable to the engineering professions of the United States, United Kingdom, and Canada.

A full account of the Conference on Unification of Engineering Standards was published on page 776 of the August, 1945, issue of MECHANICAL ENGINEERING.

Management Congress to Be Held in Stockholm, Sweden, Aug. 31 to Sept. 5, 1946

THE EIGHTH International Management Congress will be held in Stockholm, Sweden, Aug. 31 to Sept. 5, 1946. This announcement was made by William L. Batt, past-president and honorary member A.S.M.E., president, International Committee of Scientific Management, at the annual meeting of the National Management Council held in New York, Feb. 5, 1946.

The National Management Council is the American affiliate of the International Committee of Scientific Management and is composed of The American Society of Mechanical Engineers, the American Management Association, the Association of Consulting Management Engineers, the International City Managers' Association, the National Office Management Association, the Personnel Research Federation, and the Society for the Advancement of Management.

The last International Management Congress was held in Washington, D. C., September, 1938. On that occasion 1500 representatives from the United States and 21 other countries discussed over 200 papers on improvement of the techniques of management in administration, personnel, production, distribution, agriculture, and the home.

John A. Willard, member A.S.M.E., chairman, National Management Council, accepted for the Council the responsibility of sponsoring the participation of the management bodies in the United States and the contribution of management papers for the Eighth International Congress.

Erwin H. Schnell, member A.S.M.E., is chairman of the program committee of the National Management Council.

Lloyd F. Bayer Honored by Stevens Institute

LLOYD F. BAYER, member A.S.M.E., vice-president and director, Tide Water Associated Oil Company, San Francisco, Calif., received the Stevens Honor Award for "notable achievement" at the anniversary alumni dinner of the Stevens Institute of Technology, at Hotel Astor, New York, N. Y., Feb. 15, 1946.

The award was presented by Harvey N. Davis, past-president and Fellow A.S.M.E., president, Stevens Institute of Technology, Hoboken, N. J.

The citation read: "Lloyd F. Bayer, Stevens, 1914, of San Francisco, vice-president and director of the Tide Water Associated Oil Company, for notable achievement in the field of petroleum technology. By his technical skill and business acumen he has done much to develop the oil industry on the Pacific Coast and, more particularly of late, to greatly increase the supply of hundred-octane aviation gasoline for the war effort."

Stevens Honor Awards, presented for the first time in 1945, were established by the alumni association of the Institute.

Stevens Institute Honors A.S.M.E. Vice-President, A. R. Stevenson, Jr.

THE honorary degree of Doctor of Engineer was conferred on Alexander R. Stevenson, Jr., vice-president A.S.M.E., Region III, by the Stevens Institute of Technology, Hoboken, N. J., at the midwinter commencement exercises, Feb. 28, 1946.

Born in Schenectady, N. Y., Dr. Stevenson was graduated with the degree of civil engineering from Princeton University in 1914 and received the degrees of Master of Science and Doctor of Philosophy from Union College, Schenectady, N. Y. In 1917 he entered the research laboratory of the General Electric Company. After serving in the Army during World War I, he returned to the company and specialized in the application of synchronous motors to reciprocating machinery. In 1923 he was transferred to the staff of the vice-president in charge of engineering. In this capacity, he has specialized in mechanical engineering, engineering education, and the development of new products.

Dr. Stevenson is also a member of the American Society of Electrical Engineers and past-president of the American Society of Refrigerating Engineers.

Industrial-Diamond Trade Association Formed

TO PROMOTE the development of the industrial-diamond and diamond-tool industry and its service to the mechanical-processing industry, a new trade association named the Industrial Diamond Association of America, with headquarters in New York, N. Y., was formed by a group of industrial-diamond firms. The association, it is believed, will fill a long-felt need in the industry.

Athos D. Leveridge, 501 Lexington Avenue, New York, N. Y., formerly chief, diamond dies section, War Production Board, Washington, D. C., has been named executive-director and secretary-treasurer of the association. Manufacturers of diamond tools, processors, importers, and distributors of diamonds for industrial purposes compose the charter membership.

The Association's program of service to industry will stress the importance of research in the use and manufacture of industrial-diamond tools.

P.F.M.A. Elects Officers

AT the annual meeting of the Propeller Fan Manufacturers Association held at the Hotel Statler, Detroit, Mich., Feb. 13, 1946, the following officers were elected for the ensuing year: president, M. L. Aitken; vice-president, H. M. Guilbert; acting-secretary, L. O. Monroe.

Mr. Aitken is manager of Propellair, Inc., Springfield, Ohio, and Mr. Guilbert is manager of the propeller fan division of B. F. Sturtevant Company, Boston, Mass.

Chemical Exposition Held in New York, N. Y., Feb. 25 to Mar. 2

THE Twentieth Exposition of Chemical Industries sponsored by an advisory committee of the leaders in the chemical industry under the chairmanship of M. C. Whitaker, vice-president, American Cyanamid Company, was held in the Grand Central Palace, New York, N. Y., Feb. 25 to March 2, 1946.

Twelve to fifteen thousand chemists, engineers, and manufacturers daily inspected more than 375 exhibits showing equipment used in the production of abrasives, refractories, fertilizers, rubber, plastics, radio, radar, and electronics.

Of interest to the mechanical engineer were designs of processing equipment such as filters, compressors, pulverizers, and a full line of valves made of stainless steel, pure nickel, monel, pure silver, and four different types of Hastelloys.

Hastelloys

Of the newer structural materials, the nickel-based Hastelloys, widely used in the chemical industry, are designed to withstand the corrosive action of common mineral acids over a wide range of temperatures and concentrations. Developed during the war, they have been used in turbosuperchargers, jet-propulsion engines, and gas turbines where their high-temperature properties can be used to advantage.

Atomic-Energy Exhibit

A large mechanized exhibit by the American Chemical Society explained the chemical processes that are involved in the manufacture of the atomic bomb. Stressing the theme that without chemistry atomic power cannot be realized, the exhibit illustrated schematically thermal diffusion, centrifugal separation, gaseous diffusion, and electromagnetic separation.

An electron microscope was exhibited by the Radio Corporation of America. For the benefit of visitors the instrument was used to magnify particles of zinc oxide to 50,000 diameters.

Tool Engineers to Hold Annual Convention in Cleveland, Ohio

COST saving will be the theme of the exposition and annual convention of the American Society of Tool Engineers which will be held in the Cleveland Public Auditorium, Cleveland, Ohio, April 8 to 12, 1946.

The exposition will cover a wide range of products of interest to production engineers. Four-hundred classes of products ranging from screw drivers and brushes to a full range of mechanical and hydraulic presses, automatic and hand-screw machines, hydraulic riveters and punchers, resistance-welding machinery, and injection-molding machines, will be displayed. Many of the products to be exhibited will be entirely new and will represent wartime developments not previously displayed to the industrial public. Of interest will be numerous exhibits featuring quality control. These will include electronically operated high precision devices.

Technical sessions will be scheduled for the afternoons and evenings during the exposition. The keynote of the technical sessions will be: How to produce goods at lower cost while industry is paying higher wages to the men who produce the goods.

Each day during the A.S.T.E. Exposition and Convention technical motion pictures will be shown in a special theater in the Auditorium. These films will deal with all types of tool engineering and related problems.

C. L. Norton Named to Represent A.C.S.

THE American Ceramic Society named C. L. Norton, technical director, refractories division, The Babcock and Wilcox Company, New York, N. Y., manufacturers of steam-generating equipment, as the Society's representative to the Heat Transfer Division of The American Society of Mechanical Engineers.

Mr. Norton is active in the Refractories Section of the American Ceramic Society where he has helped to develop standard methods of determining heat-transfer coefficients for refractory products.

Plastics Award to Honor Peacetime Contribution

FOR the first time since it was established in 1941, the John Wesley Hyatt Award sponsored by the Hercules Powder Company, Wilmington, Del., will be presented on the basis of a peacetime contribution to the plastics industry. The award consists of a gold medal and $1000.

Members of the award committee for the 1945 competition are: Richard F. Bach, dean of education, the Metropolitan Museum of Art; William Iler Beach, chief plastics engineer, North American Aviation, Incorporated; Neil O. Broderson, president, Society of the Plastics Industry; Bradley Dewey, president, American Chemical Society; Charles F. Kettering, member A.S.M.E., vice-president in charge of research, General Motors Corporation; Edward R. Weidlein, director, Mellon Institute of Industrial Research; Gerald Wendt, editorial director *Science Illustrated*, and William T. Cruse, committee secretary.

Five points determine eligibility for the award: (1) its practicality, with special reference to availability of materials and production equipment, and to restrictions in fields of application; (2) degree of permanence of the development, and the scope for further applications in the plastics industry and similar fields; (3) importance of the achievement to the plastics industry in the year for which the award is given, regardless of the year of its conception; (4) potentialities of the development in future years; ingenuity required in the development of the achievement.

Books for Mechanical Engineers, 1945

DURING the course of a year the Engineering Societies Library is asked to recommend books on specific subjects. A list of some of the significant books of interest to mechanical engineers, compiled by the staff of the Engineering Societies Library is given for convenience of A.S.M.E. members. Some equally good books have been omitted because of the desire for a short list.

INDUSTRIAL ELECTRIC FURNACES AND APPLIANCES. By V. Paschkis. Vol. 1. Interscience Publishers, Inc., New York, N. Y., 1945, 232 pp., $4.90. Covers thermal, electric, and economic principles applying to all types of furnaces and appliances. Discusses arc furnaces and electrode melting furnaces, with special attention to ferroalloy furnaces. Emphasis is placed on the thermal aspects of furnace design and operation. A second volume will cover induction, capacitance, and resistance heating.

THE COMING AGE OF ROCKET POWER. By E. Pendray. Harper & Brothers, New York, N. Y., 1945, 244 pp., $3.50. The evolution of the rocket principle, from its discovery ages ago to such modern developments as the bazooka and rocket plane, is presented in nontechnical style.

STRENGTH OF MATERIALS. By A. P. Poorman. Fourth edition. McGraw-Hill Book Company, New York, N. Y., 1945, 339 pp., $3. This edition of a standard textbook includes among other changes an article on aluminum, duralumin and magnesium columns in airplanes, and three articles on the derivation and use of the parabolic column formula for steel columns.

REFRIGERATION AND AIR-CONDITIONING ENGINEERING. By B. F. Raber and F. W. Hutchinson. John Wiley & Sons, Inc., New York, N. Y., 1945, 291 pp., $4. Covers the fundamental principles of refrigeration and air conditioning, including cycles of vapor refrigeration systems, complex compression cycles, absorption cycle, periodic heat transfer, psychrometric principles, ventilation systems and duct design. Describes the heat pump, radiant heating, porous-coil humidifying, etc.

THE MODERN GAS TURBINE; Its Uses as an Exhaust Turbosupercharger or Prime Mover in all Fields of Service Including Jet Propulsion. By R. T. Sawyer. Prentice Hall Inc., New York, N. Y., 1945, 216 pp., $4. Covers history and fundamental theory, but gives more attention to use of the gas turbine and includes descriptions and illustrations of equipment.

PRODUCTION ILLUSTRATION, the Techniques and Applications of Perspective Engineering Drawings. By J. Treacy. John Wiley & Sons, Inc., New York, N. Y., 1945, 202 pp., $4. Covers the actual preparation of production drawings: drafting, shading techniques, short-cuts, perspective methods, and reproduction aids. Practical applications of illustration to the problems of industrial production are included.

MACHINE-TOOL WORK, FUNDAMENTAL PRINCIPLES. By W. P. Turner and H. F. Owen. Second edition. McGraw-Hill Book Company, Inc., New York, N. Y., 1945, 364 pp., $3. Covers the fundamental problems that are common to all kinds of machine-tool work, including the lathe, planer, shaper, milling machine, drilling machine, and grinding machine.

Sections

Chicago Section Hears About Its City's Airport Problem

ON Feb. 5 in the Little Theater, Civic Opera Building, Chicago, Ill., E. P. Lott, director of design, buildings, and airports, United Air Lines, and chairman of Chicago Air Lines Technical Committee, spoke on "The Chicago Airport Problem." Ninety-eight were present to hear Mr. Lott tell of the time and effort spent on this problem. His talk was illustrated with lantern slides. Mr. Lott said that the Chicago problem was handled with the Idlewild airport in mind. At present the Municipal airport has grown from an original 160 acres to 320 to 640 acres in eighteen years. The present port moves about 120 planes an hour, and it appears that it is now too small in size, the consequence being that future air travel may by-pass Chicago as a main terminal. Five sites were then selected as a possibility for an airport; a highway to Chicago's loop will be necessary and has already been laid out. Mr. Lott said that the whole problem is very substantial in scope as well as in cost, but should render a valuable community service in transportation facilities.

Heat Transfer Meeting

On Feb. 19 a meeting was held in the Little Theater, Civic Opera Building, sponsored by the Heat Transfer and Fluid Flow Division of the Section. The speaker was Dr. George A. Hawkins, member A.S.M.E., professor of thermodynamics, Purdue University, and his subject was "Heat Transfer in Gun Barrels." The meeting chairman was Dr. M. Jakob who made a few opening remarks on the "why" of heat transfer and fluid flow, and then introduced the speaker. Dr. Hawkins presented a very interesting picture of the heat-transfer problems in a gun barrel. His talk was accompanied by lantern slides and was limited to those released by the Armed Forces. Sixty-two members were present.

Junior Division

The Junior Division of the Chicago Section has installed a new type of project for the 1945–1946 season. A seminar program is being sponsored which includes 13 meetings devoted to the purposes of outlining a broader education for young engineers, and acquainting them with the responsibilities, future prospects, and background and training required in the various fields open within the engineering profession. Eight meetings have already been held.

"Human Relations for Engineers," speakers: Dr. Robert K. Burns, Industrial Relations Center and Dr. William Whytem, professor of sociology, University of Chicago. "The Engineer and Patents," speaker: J. O. Lange, engineer of patents, Crane Company. "Advanced Technical Education," speaker: Dr. L. E. Grinter, vice-president, Illinois Institute of Technology. "Self-Expression for Engineers," speaker: Prof. R. W. Gerard, department of physiology, University of Chicago. "Business Administration," speaker: Prof. J. W. Towle, school of commerce, Northwestern University. "Sales Engineering," speaker: F. A. Faville, president, Faville-Le Valley Corporation. "The Engineer in Production," speaker: E. J. De Witte, vice-president, Wallace Supplies Manufacturing Company.

The subjects of the meetings to be held in the future are: "The Engineer's Part in Advertising," speaker: R. H. Bacon, vice-president, Kreicker and Meloan, Inc. "Product Design," speaker: M. G. Hawkins, Barnes and Reinecke. "The Engineer in Research," speaker: Prof. F. W. Hutchinson, department of mechanical engineering, Purdue University. "Consulting Engineering," speaker to be announced. "The Engineer in Management," speaker: Alex D. Bailey, past-president A.S.M.E. vice-president, Commonwealth Edison Company.

The interest shown in these seminars has been gratifying. Attendance has averaged over 50 junior members at all meetings. Many members have attended all of the sessions, and each seminar has been conducted as a dinner meeting. The speaker talks for a half to three quarters of an hour, and there is a lively discussion-and-question period following the talks. A number of returning veterans are members of the group, and all express their interest and the benefit they gain from the seminars. The program has been arranged and conducted by the junior executive committee of the Chicago section, comprising: R. C. Clough, Illinois Tool Works; F. D. Cotterman, Crane Company; H. S. Nachman, R. M. Moffett and Company; D. I. Payne, Teletype Corporation; and J. D. Pierce, Crane Company.

Gyroscope Topic at Boston Section Meeting

On Feb. 21 at Northeastern University, Boston, Mass., the subject was "Jobs for the Gyro," and the speaker, Prof. C. S. Draper of the Massachusetts Institute of Technology. Professor Draper explained the principles of the gyroscope, showing how it processes. He demonstrated its action under various conditions by a working model, and discussed the application of the gyroscope to direction finders, stable verticals, stable horizontals, and gunsighting. One hundred and eighty-five members and guests enjoyed Professor Draper's talk.

J. C. Cone of Pan American Airways Speaks at Akron-Canton Section

On Feb. 28 a meeting was held at Semler's Tavern, Cuyahoga Falls, Ohio, when J. Carroll Cone, a World War I combat pilot, gave a talk on "International Air Transport Policy." Mr. Cone, who is at present assistant vice-president of Pan American Airways, has had 27 years' experience flying all types of planes, and has flown over 8000 hours and 1,000,000 miles as a pilot. In the course of his lecture he said that new records had been set from New York to London, of 12 hours and 10 minutes, also from New York to Cuba of 2 hours and 10 minutes. He described the new ships of Pan-American Airways on order, which will carry 300 passengers at 7 miles per min. A detailed account was given of the recent air-transport agreement between Great Britain and the United States which is binding for one year. The meeting was concluded with an open discussion. Forty-eight were present to hear Mr. Cone.

J. CARROLL CONE

Central Illinois Section Hears E. V. Benton

On Feb. 14 at the University Club, Peoria, Ill., E. V. Benton spoke on "Elimination of Smoke From Locomotives by Air Jets." Mr. Benton discussed research development of air jets and their application to locomotives. He said that air jets cost money to operate and the efficiency of the boiler is apparently unaffected. He confirmed that jets eliminate smoke when properly handled. Sixty were in the audience.

New Electrical Standards Explained at Cincinnati Section

At the meeting on Feb. 14 at the Schneider Foundation, Cincinnati, Ohio, the speaker was Ed. J. Rivoira, Junior member A.S.M.E., electrical engineer, Cincinnati Milling Machine Company, whose topic was "New Electrical Standards of the Machine Tool Builders Association." Mr. Rivoira has been a member of the electrical standards committee of the M.T.B.A. since 1942, and in September, 1945, he was named chairman. He gave a detailed report of the "Proposed Machine-Tool Electrical Standards," and "Automotive Standards," and explained how and why they were different. He also illustrated the entire Standards with slides and large charts, and showed some 80 slide-films made by the General Motors Company illustrating "What to Avoid." A lively question-and-answer period followed. There were 59 in the audience.

Future of the Gas Turbine Prophesied at Baltimore Section

On Jan. 28 at the Engineers' Club, Baltimore, Md., J. I. Yellott, member A.S.M.E., director, Institute of Gas Technology, Chicago Ill., gave a talk entitled "Gas Turbines for Transportation Applications." He was introduced by H. F. Brush, who studied under Professor Yellott when the latter was head of the mechanical-engineering department at Stevens Institute of Technology, Hoboken, N. J. In his talk Professor Yellott described the gas turbine as "a revolution in power," and said the crossing of the continent in a little over four hours by a jet-propelled Lockheed P-80 plane had been made possible only by use of a gas turbine; he predicted that the gas turbine would propel planes through space at supersonic speeds as soon as the aircraft builders could design a plane capable of withstanding such speed. He also predicted eventual success in the project in which he and other scientists are attempting to develop a coal-fired gas-turbine locomotive which will deliver approximately the efficiency of a Diesel engine at much lower operating costs. The meeting was conducted by James H. Potter and the attendance was 230.

The annual President's Night was held at Johns Hopkins University on Feb. 25. D. Robert Yarnall, president A.S.M.E., and Dr. Alexander R. Stevenson, Jr., regional vice-president A.S.M.E., were the guests of the Section. The program ncluded a talk on "Rehabilitation of German Utilities," by Col. L. G. Smith, assistant to the general superintendent of the Consolidated Gas and Electric Company.

Dayton Section Has Talk on Modern Gaging Methods

The Jan. 15 meeting at the Engineers' Club, Dayton, Ohio, had as the speaker R. E. Lilleberg of the Sheffield Corporation, whose subject was "Gaging Methods and Quality Control." Mr. Lilleberg discussed modern gaging methods and equipment for obtaining proper dimensions. He illustrated his talk with slides. Forty were present.

"Magnesium Night" was held on Feb. 19 at the Engineers' Club, with a dinner and program consisting of an address by T. S. Atkins, executive vice-president, The Magnesium Association, on postwar applications of magnesium, and a talk by E. S. Bunn, metallurgical manager, Revere Copper and Brass Inc., on "The Working of Wrought and Extruded Magnesium Alloys." Mr. Bunn discussed the properties of the several wrought and extruded magnesium alloys, and the problems of techniques of various methods of fabrication and treatment. C. H. Kuthe, technical adviser to Revere Copper and Brass Inc., assisted during the interesting discussion which followed. One hundred and ten members and guests were in the audience.

Automatic Controls Discussed at Cleveland Section

A meeting was held on Feb. 14 at the Cleveland Engineering Society Building, Cleveland, Ohio. W. H. Steinkamp, guest speaker, gave a talk entitled "Some Practical Aspects of Automatic Control." He discussed the types of automatic-control instruments which are available, and explained their application to process work. The audience totaled one hundred.

OFFICERS AND GUESTS OF THE BALTIMORE SECTION AT DINNER MEETING

(*Seated, left to right:* H. H. Hildebrand, chairman, Maryland Section A.I.E.E.; Col. L. G. Smith, speaker of the evening; D. Robert Yarnall, president A.S.M.E.; J. H. Potter, chairman, Baltimore Section; A. R. Stevenson, Jr., vice-president, A.S.M.E., Region III; A. G. Christie, past-president A.S.M.E. *Standing, left to right:* H. W. Woodward, vice-chairman, Baltimore Section; H. H. Angell, vice-chairman, Maryland Section, A.I.E.E.; L. E. Carter, secretary-treasurer, Baltimore Section; W. B. Kownhoven, dean of engineering, Johns Hopkins University; E. Hansen, secretary-treasurer, Maryland Section, A.I.E.E.)

"Developments in Welding Art" Topic at Ft. Wayne Section

A dinner meeting was held on Feb. 7 at the Chamber of Commerce Building, Fort Wayne, Ind. Dr. Samuel L. Hoyt, technical adviser, Battelle Memorial Institute, Columbus, Ohio, was the guest speaker, and his subject was "Recent Developments in the Welding Art." Dr. Hoyt, who recently returned from Germany where he spent three months investigating its wartime activities in metallurgical research, gave a very interesting talk on the advances in welding which were brought about by war necessity and research. He told of the metallurgical problems that had to be met so that welding could be adapted to the production of ships, airplanes, tanks, and other war materials. Fifty members and guests enjoyed the lecture, which was followed by a general discussion period.

Dr. Lionel S. Marks Speaks at Inland Empire Section

On Jan. 17 at the Davenport Hotel, Spokane, Wash., Dr. Lionel S. Marks, Fellow A.S.M.E., professor emeritus of mechanical engineering, Harvard University, Cambridge, Mass., spoke on "Jet Propulsion and Rockets." In his talk Dr. Marks said that jet-propelled planes will be used for higher-speed transportation where fuel economy is not an important factor. The present type planes, he said, will be used for economical slower-speed operation. Two hundred and forty-six were in the audience.

New London Section Hears James B. Reid

A meeting was held on Feb. 14 in the Mohican Hotel, New London, Conn. The speaker was James B. Reid, the Dow Chemical Company, who talked on "Magnesium Alloys." Mr. Reid told his audience that magnesium is the lightest structural metal known to man, fully $33^1/_3$ per cent lighter than aluminum. The metal is obtained from sea water and from salt-water wells, purified and electrolyzed to form the pure metal. The metal is worked by most of the common processes. It may be sand- or die-cast, extruded, rolled into sheet, machined, drawn and cupped, and spun, but the metal cannot be cold-worked too severely without heating to a temperature range of 400–600 F at which it is easily worked. He said that during the war all magnesium went into aircraft structures. Seats, gun-turret parts, wheels, and wings were some of the items made from magnesium. The metal is now coming into the household-appliance field in the form of griddles, and for handtools such as grinders, drills, and other products where saving even one pound of weight means much to the comfort of the operator. The speaker remarked that magnesium will probably not be used for light-gage pots or pans because of its inflammable characteristics. With the talk a motion picture was shown. There were 45 members and guests present.

"Measurement of Surface Finishes" Topic at New Haven Section

At the Feb. 13 meeting held in the Ceriani Cafe Mellone, New Haven, Conn., W. Mikelson, of the general engineering and construction laboratory, General Electric Company, Schenectady, N. Y., spoke on "The Measurement of Surface Finishes." Mr. Mikelson told of the work of his company and American Standards Association on developing standards on surface finishes. He described the methods used, such as comparison blocks for "touch and sight," stylus instruments (profilometer and Brush surface analyser), air-jet measuring device, and many others. The talk was illustrated with slides.

"Chemical Cleanup" Talk At North Texas Section

On Jan. 28 at the Melrose Hotel, Dallas, Texas, Guy Williams addressed the group on the subject "Chemical Cleanup." He said that many boilers and heat exchangers have been cleaned by the Dowell method of acid cleaning, and that the results have been excellent and the cost competitive with mechanical cleaning methods. Care is required, he explained, in handling this process, but under supervision of trained engineers, it is safe for both equipment and personnel.

"A Sieve for Confusion" Interests Ontario Section

At Hart House, University of Toronto, Toronto, Ont., Can., on Feb. 14, Morley J. Lazier, member A.S.M.E., consulting engineer of Toronto, spoke on "A Sieve for Confusion." In his talk Mr. Lazier dealt with an extension of the method of classification by properties to eliminate confusion when there are a large number of properties requiring different action for each one. The talk was delivered in the speaker's inimitable and humorous manner, and was enjoyed by the 100 members and guests in the audience.

Dr. Lionel S. Marks Speaks at Oregon Section

On Jan. 24 one of the largest audiences of engineers ever gathered in Portland, Ore., heard Dr. Lionel S. Marks, Fellow A.S.M.E., professor emeritus of mechanical engineering, Harvard University, Cambridge, Mass., speak on "Jet Propulsion and Rockets." Speaking to members of the A.S.M.E., the A.S.C.E., and the A.C.M., Dr. Marks pointed out that the compactness and weight of the power unit is a determining factor in relation to permissible speeds of jet-propelled planes. As to rocket planes, he said their great advantage is the enormous concentration of power in a rocket.

Those present, totaling almost 300, expressed great satisfaction in such a worth-while evening.

Kenneth W. Ketchum presided at the meeting.

Forecast of the Economic Picture at Kansas City Section

On Feb. 11 at the University Club, Kansas City, Mo., Dr. T. Bruce Robb of the Federal Reserve Bank, gave a talk on "The Economic Picture—Past, Present, and Future." Dr. Robb said that the two keys which determine the future are: the large backlog of civilian buying power; and the great amount of liquid assets which will go for food, clothing, construction, and automobiles. The increases in liquid assets, he said, are in bank deposits which are made up of bank loans and government bonds, and not currency, and that the rise of liquid assets over production represents inflation. Forty-nine were present.

Symposium on Variable-Speed Drives Held at Providence Section

At a meeting held in the Providence Engineering Building, Providence, R. I., on Feb. 5, a symposium on variable speed drives was presented. Dr. John A. Hrones, member A.S.M.E., associate professor of mechanical engineering, Massachusetts Institute of Technology, Cambridge, Mass., spoke on the design and operating principles of widely used mechanical variable-speed drives; George F. Maglott, Brown & Sharpe Manufacturing Company, gave a talk on the fundamentals and advantages of fluid mechanics as used in hydraulic transmissions and R. B. Moore, General Electric Company, Schenectady, N. Y., gave a general talk on all types of electrical adjustable-speed drives. The papers were deemed excellent by the audience of one hundred forty five.

A.S.M.E. Member Is Speaker at Rock River Valley Section

On Feb. 21 at the Faust Hotel, Rockford, Ill., the speaker was James W. Owens, member A.S.M.E., director of welding, Fairbanks, Morse and Company, whose subject was "Routine Inspection of Machinery Weldments and Salvage by Precision-Welding." Mr. Owens, who has done considerable research work in welding, covered the types of welds for various conditions, establishment of procedures for welders, and magnaflux patterns for testing. He elaborated on salvage operations, and showed how expensive weldments that had been scrapped in machining operations were saved by precision-welding. He also showed forms for welding inspection. Slides accompanied the talk. The meeting was preceded by a dinner.

Illustrated Talk on Gas Turbine at Detroit Section

An interesting meeting was held on Feb. 5 in the Rackham Building, Detroit, Mich., when S. F. Richardson of the General Electric Company, spoke on "The Gas Turbine in Jet Propulsion." Mr. Richardson described

the current types of turbines, and showed slides of jet turbine propeller-powered planes, and a movie of Bell D-59 jet plane. There was a lengthy discussion after the talk on all phases of turbine design and use. The audience totaled 175.

Metropolitan Section Enjoys Social Event

Approximately 250 Metropolitan Section members and guests attended the Annual Metropolitan Section Night on Monday, Feb. 25, at A.S.M.E. Headquarters. The evening's high light was an entertaining lecture presented by Prof. R. M. Sutton on the subject of "From Stars to Atoms and Back Home the Same Night." As the title implies, Professor Sutton's talk, while on a technical subject, was arranged and presented from the angle of entertainment with illustrative experiments and pictures. The talk was preceded by a buffet supper which afforded the members and guests a fine opportunity to get together socially. C. E. Davies, secretary of the A.S.M.E., acted as toastmaster, introducing Professor Sutton and R. F. Gagg, regional vice-president.

Milwaukee Section Visits Malting Production Plant

On Feb. 13 a visit was made to the plants of Froedtert Grain and Malting Company, Inc., Milwaukee, Wis., to study modern malting-production methods. The tour included malthouse, pilot plants, laboratories, power plant, and a unique device for unloading freight cars. The company is the largest commercial malting firm in the world and its methods, equipment, and laboratories are the most modern of their kind in use today. A dinner was served at the Tanner-Paul Legion Post in West Allis, followed by description of the malting process and the history and growth of the Froedtert organization by Kurtis R. Froedtert, president and chairman of the board of that company; J. P. Hessburg, its vice-president; Dr. L. E. Ehrnst, chief chemist, and L. A. Corwin, general superintendent of plants.

J. R. Carlson Speaks at Colorado Section

The regular dinner meeting was held on Feb. 8 in the Oxford Hotel, Denver, Colo. The speaker of the evening was J. R. Carlson, member A.S.M.E., Westinghouse Electric Corporation, Philadelphia, Pa., who spoke on "The Gas Turbine's Place in Electric-Power Generation." Mr. Carlson's illustrated talk covered a brief outline of theory and cycle arrangements, followed by a description of the limitations and practical application of the gas turbine as a prime mover for electric generation, its use in jet propulsion, and its possibilities as locomotive power. Sixty-one were in attendance.

Philadelphia Section Has Three Important Meetings

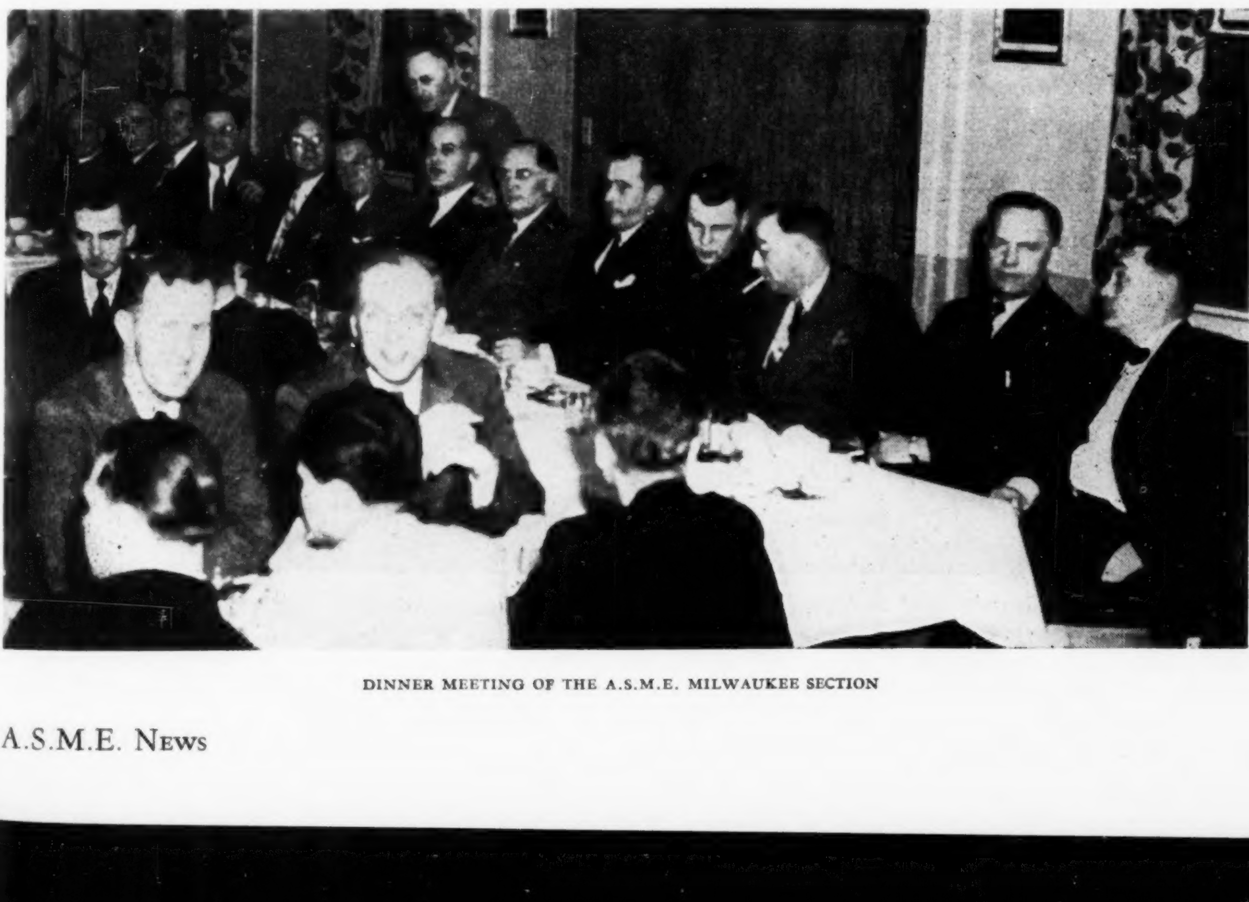
On Feb. 12 at the University of Pennsylvania the second of the series in the special Professional Division meetings was held under the auspices of the Process Industries Division. Louis Hull of the F. J. Stokes Machine Company, discussed "High-Vacuum Processing," and Dr. Earl W. Flosdorf of the same company, gave a talk on "Freeze Drying." Mr. Hull explained various operations and results which have been facilitated or made possible by high vacuum, including drying, impregnation, distillation, electroplating, and thermal insulation. Dr. Flosdorf presented demonstrations and slides covering development of the freeze-drying process for production of blood plasma, penicillin, and frozen foods.

Dr. J. H. Rushton was the speaker at the Feb. 26 meeting at the Engineers' Club, Philadelphia, Pa. His talk on "Future Possibilities for Use of Oxygen in Industrial Processes" was one of the finest discussions of the future uses of oxygen in industrial processes that the audience had ever heard. His explanation of how oxygen can be used to speed up reactions in the steel, coal, and gas industries was very illuminating. Dr. Rushton also gave an excellent explanation of the German synthetic-fuel production methods developed for war purposes. Eighty members and guests enjoyed the program.

The third meeting of the Professional Division series was held at the University of Pennsylvania on Feb. 19, sponsored by the Aviation Division. Victor Dallin, chief of the Philadelphia Bureau of Aeronautics, and Howard Shafer, manager of the Philadelphia Airport, spoke on the subject of "How Philadelphia Intends to Meet Its Airport Requirements." Mr. Dallin outlined plans for the immediate expansion of the Southwest Airport from 111 acres to 2200 acres, with runways having a minimum length of 6000 ft. Mr. Shafer stressed the wide margin which the expanded facilities will provide to meet the requirements of modern air liners.

Trenton Committee of Philadelphia Section

The Trenton Committee of the Philadelphia Section held a meeting on Feb. 25, at the Carteret Club, Trenton, N. J., when Otto Kuhler, design consultant of the American Car and Foundry Company, presented a very



DINNER MEETING OF THE A.S.M.E. MILWAUKEE SECTION

interesting talk on new developments in the field of railroad transportation. The talk was illustrated with many colorful slides and a movie showing the very latest rail cars and locomotives.

"The Construction of the LST Ships for the U. S. Navy" was the subject of an illustrated lecture given by Frederick Cole of the Dravo Corporation, Pittsburgh, Pa., at the March 25 meeting held at the Carteret Club, Trenton, N. J. The novel assembly-line technique used by Mr. Cole's company during the war years was of particular interest to those in the fabrication field.

Plainfield Section Hears Malcolm F. Judkins

The meeting on Feb. 20 at the Elks' Club, Elizabeth, N. J., featured Malcolm F. Judkins, member A.S.M.E., chief engineer of the carbide division of the Firth Sterling Steel Company, McKeesport, Pa., who spoke on "Engineering Materials From Powder." Mr. Judkins has been affiliated with the Firthite division of his company since the inception of carbide manufacture in 1929. In his lecture Mr. Judkins said that the application of powdered metals for sintered carbide tools has been demonstrated in mass production during the war, but that the broad field of application of engineering materials from powder will be the important postwar development in scientific research for high-temperature alloys. With the talk a 45-minute sound film was given, covering the manufacture of sintered carbide tips and tools. The film also showed a series of studies of actual usage of carbide tools in various metal-cutting operations, and provided an interesting subject for those concerned with modern methods of high-speed production.

As a prelude to Mr. Judkins talk, John A. Goff, dean, Towne Scientific School, University of Pennsylvania, spoke on "Engineers Contribution to Postwar Recovery." The audience numbered 105.

"Development of Aircraft Engines" at St. Joseph Valley Section

Normal Tilley, of the aviation division, Studebaker Corporation, was the speaker at the Feb. 14 meeting in the Hotel LaSalle, South Bend, Ind. His subject was "Development of Aircraft Engines." Mr. Tilley traced the history of the aircraft engines from the Manley type of 1901 down to the Cyclone of 1945, and the jet type of 1946. He discussed requirements of an ideal engine, and the difficulties encountered by the steam, mercury, and other types. Jet and gas-turbine engines were described, as well as the items of power-plant equipment. The question-and-answer discussion period following his talk was most interesting.

Prof. Howard Hassell at Utah Section

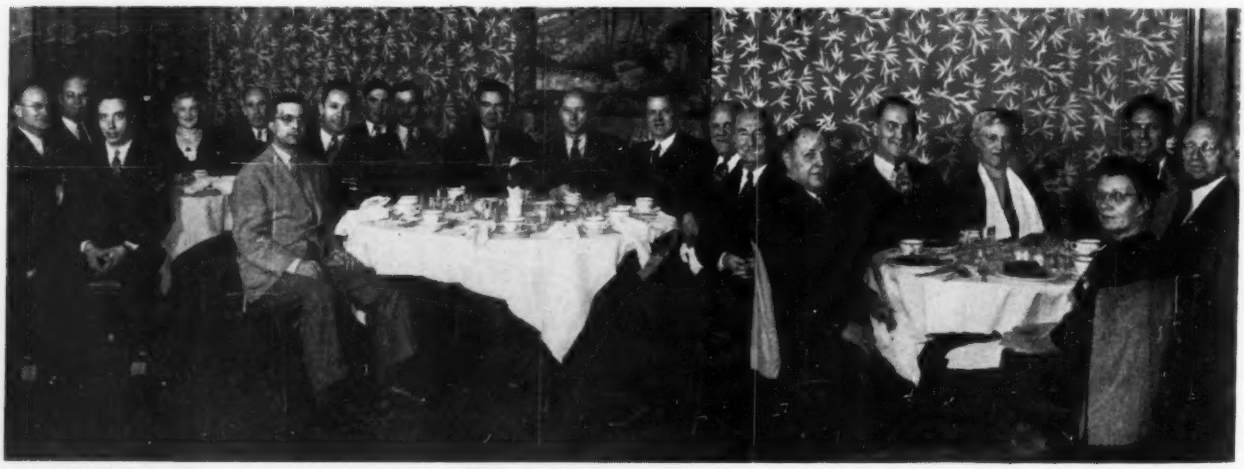
On Feb. 25 at the Union Building, Salt Lake City, Utah, Prof. Howard J. Hassell of the department of mechanical engineering, University of Utah, who is on leave of absence as assistant chief engineer, fuel and heating section, Office of the Service Command Engineer, Headquarters of the Ninth Service Command, Fort Douglas, was the featured speaker. His experiences during the time he has been with the Service Command are the result of assignments from the Pacific to the Atlantic Coasts. His subject, "The B.T.U. Trail (With Detours)" was highly entertaining. Professor Hassell explained to the audience how many heating and power installations were rushed through during the war years with a lack of engineering supervision, and emphasized the need for engineering education of the public to conserve our natural fuel resources. Dr. A. R. Olpin, new president of the University of Utah, was the guest of honor.

West Virginia Section Has Annual Joint Meeting With A.I.E.E.

The annual joint meeting with the West Virginia section of A.I.E.E. was held on Jan. 22 at the Daniel Boone Hotel, Charleston, W. Va., when the speaker was F. C. Rushing, member A.S.M.E., research engineer, Westinghouse Electric Corporation. Mr. Rushing spoke on "Vibration and Balancing," a subject of interest to both sections. He illustrated the fundamentals by examples from actual experience, and had the undivided attention of his audience throughout the talk. Members and visitors totaled 110.

Washington, D. C., Hears Talk on "Citizenship"

The meeting on Jan. 10 was held in the Potomac Electric Power Company auditorium. A dinner preceded the meeting, and following the dinner, Rudolph Michel, presiding officer, introduced Dr. Roy V. Wright, past-president A.S.M.E., who in turn introduced the speaker of the evening, Dr. Alexander Stephenson, whose subject was "Citizenship." Dr. Stephenson cited examples of how engineers may use their talents to improve the communities in which they live, such as advising civic committees on proposed engineering projects. He enumerated the advantages and disadvantages of the engineer in carrying out civic projects, spoke of the lack of unity among engineers as compared to other professions, and remarked that the latter was something engineers must correct to become effective in civic matters. He made the suggestion that adult education on human relations and related subjects be used as a device to enlist the interest of engineers in civic affairs. The discussion that followed was high-lighted by remarks from Dr. Wright, General Koontz, and Messrs. Hanrahan, Reed, Snelling, and DeShasier.



A.S.M.E. PLAINFIELD SECTION AT DINNER MEETING

(*Left to right:* W. L. Boswell, G. W. Nigh, P. Fimble, Mrs. Nigh, J. D. Potter, *chairman;* M. Grubelich, H. Ritter, H. Nikola, student branch, Rutgers University; A. DeMatteo; M. F. Judkins, *speaker;* E. Ball, John A. Goff, dean, Towne Scientific School, University of Pennsylvania; W. Chaffe, P. Osterman, C. Tyroff, E. Franz, Mrs. E. Franz, Mrs. E. C. Schultze, C. O. Heath, Rutgers University; and E. C. Schultze.)

On Jan. 24 a second meeting was held at the same auditorium when Prof. A. G. Christie discussed "The Design of Modern Boiler Plants." He pointed out the developments and trends of the latest boiler design, enumerating five important features. One hundred were in attendance.

"Magnesium and Its Alloys" Featured at Waterbury Section

A meeting was held on Feb. 26 in the Hotel Elton, Waterbury, Conn., when James B. Reid of the Dow Chemical Company, gave a talk on "Magnesium and Its Alloys." Mr. Reid traced the development of magnesium prior to World War II and continued with a description of its characteristics, methods of fabrication, and uses. A sound movie accompanied the talk, and a lengthy question-and-answer period followed, indicating the interest of the audience.

Western Washington Section Hears Dr. Lionel S. Marks

Dr. Lionel S. Marks, Fellow A.S.M.E., professor emeritus of mechanical engineering, Harvard University, Cambridge, Mass., gave a lecture on "Jet Propulsion and Rockets," at the Jan. 21 meeting at the University of Washington, Seattle, Wash. Dr. Marks gave the theory of jet propulsion, and illustrated with slides to bring out comparison with the conventional gas-engine airplane. Five hundred were in the audience.

Student Branches

University of Alabama Branch

The second meeting since the war ended was held in Graves Hall on Feb. 4. Election of officers was postponed until a later meeting, to allow time for all members to become acquainted. Prof. D. H. Shenk, member A.S.M.E., spoke of the A.S.M.E. Spring Meeting at Chattanooga, Tenn., April 1, 2, and 3, at which time students are to present creative papers in competition for a $50 prize.

The program consisted of an interesting talk on jet propulsion by Earl Karm, a student member, and the showing of a film entitled "The Student Engineer," which was made at the University of Alabama.

On Feb. 18 a meeting was held in the Engineering Building, but because of inclement weather the attendance was poor and election of officers was postponed. Members were urged to advertise the reopening of the University of Alabama branch of A.S.M.E. in order to enlarge the membership. A student member, Mr. Smith, then gave an interesting talk on "The Operation of Machinery in Cold Climates." When in the Army Mr. Smith was in a group detailed to charter the opening of an oil well and pipe line in northern Canada, and he was therefore well qualified to speak from experience.

College of the City of New York Branch

The opening meeting of the semester was held on Feb. 21 and was concerned chiefly with organization and planning. The new president, Jay Pullman, addressed the members on matters relating to the internal structure of and benefits derived from the A.S.M.E. He also emphasized the importance of creating as closely knit a local group as possible. Prof. S. J. Tracy, member A.S.M.E., honorary chairman, gave a short address, opening officially the activities of the branch for this semester.

University of Colorado Branch

The Jan. 16 meeting in the Engineering Administration Building was called to order by chairman John Kelley. Plans were discussed for a dance to be sponsored by the branch. New officers for the coming March semester were elected as follows: Kenneth Marquand, student chairman; Fred Reed, vice-chairman; Betty Beck, secretary; and Frank Squier, treasurer. The program was devoted to motion pictures.

Colorado State College of A. and M. Arts Branch

The branch met on Feb. 11 in the Mechanical Building to hear a lecture on atomic energy by Dr. Louis R. Weber, head of the physics department. Dr. Weber reviewed the history of the development of atomic-energy science, and explained the contents of the Smyth report. During the business meeting members voted unanimously in favor of holding the regional spring conference at the University of Colorado and recommended the dates of May 3 and 4.

On Feb. 18 another meeting was held in the Mechanical Building, when three reels of sound movies on aluminum production and forming were shown. A new 16-mm sound projector has recently been purchased by the engineering division of the college.

Cornell University Branch

During the month of January several films obtained from the U. S. Bureau of Mines and the Naval Diesel Training School at Cornell were shown. "The Story of Gasoline," "The Diesel Engine," and "Fuel Injection Systems," presented a good background to those students who had not already taken internal-combustion-engine courses. "The Story of the Spark Plug" was of particular interest, as it showed the major steps in production from mining sillimanite to the heat-treatment processes and final testing of the plugs.

At the final meeting of the term Gifford Bull, an aeroydnamics instructor at Cornell, addressed a combined meeting of the Ithaca Section and the branch. Mr. Bull discussed the fascinating operation of several types of auto-pilots. As he had worked with the Sperry Gyroscope Company, and is an experienced pilot himself, he was able to give a great deal of first-hand information. He brought out the point that the auto-pilot will be used more and more in the future for landing planes, since during that point of flight the human pilot has too much to think about if he is to land the plane efficiently. Although a boon to long-distance flying, the auto-pilot is too delicate an instrument to be trusted alone with human lives, without having a human pilot along. A brief outline of the use of radio beams and auto-pilot principles in radar and V-bombs, during World War II was also given.

Election of officers for the spring term gave the chairmanship to Seaman Robert J. Miller. Randall Johnson was elected vice-chairman, and Jarman Kennard, secretary-treasurer.

Illinois Institute of Technology Branch

At the Feb. 7 meeting in Room 305, Main Building, Dr. John T. Rettaliata, junior member, A.S.M.E., director of the department of mechanical engineering at the Illinois Institute of Technology, gave a short talk on the many advantages to be derived from student membership in the A.S.M.E., and also spoke of the importance of transferring membership

1946 Annual A.S.M.E. Group Student Meetings

	Group	*Host*	*Place*	*Date*
I	New England	Rhode Island State College	Kingston, R. I.	May 4
II	Eastern	Pratt Institute	Brooklyn, N. Y.	April 23
III	Alleghenies	To be announced	To be announced	To be announced
IV	Southern	University of Tennessee	Chattanooga, Tenn. (In conjunction with A.S.M.E. Spring Meeting)	April 2
V	Midwest	University of Notre Dame	Notre Dame, Ind.	April 29–30
VI	North Central	University of Missouri	St. Louis, Mo.	April 12–13

to the junior organization as soon as possible after graduation. After his talk, the honorary chairman, Dr. R. A. Budenholzer, Junior member A.S.M.E., was introduced by president, Tom Blim. Dr. Budenholzer discussed the organization and purpose of the Spring Group Meeting of the student A.S.M.E. to be held at Notre Dame University in the near future. He set forth the rules for writing of student papers, the methods by which these papers will be judged, and the various awards to be given to those having the best papers. Officers were then elected for the coming semester, as follows: James Woodling, chairman; Calvin Zehnder, vice-chairman; John Beam, treasurer, and Robert Boyer, secretary.

University of Kansas Branch

The Jan. 24 meeting was held in the auditorium of Marvin Hall on the campus. Officers were elected for the spring semester as follows: James R. Gregath, chairman; Harry A. Dalby, vice-chairman; Wilbur F. Pro, secretary, and Robert E. Smith, treasurer. A two-reel film entitled "Wheels Across India" was shown and thoroughly enjoyed. Prof. E. S. Gray, member A.S.M.E., head of the mechanical-engineering department, announced that the branch would be hosts to the Kansas City Section of the A.S.M.E. some time in April.

Kansas State College Branch

The last meeting of the fall semester was held on Jan. 24 in Engineering Hall. Prof. Linn Helander, head of the mechanical-engineering deparment, and vice-president A.S.M.E., Region VIII, gave a talk on the Society, its organization and purpose. He also spoke of the A.S.M.E. Annual Meeting which he attended in New York in November, 1945.

Marquette University Branch

The meeting on Feb. 5 was held in the Engineering Building. The membership committee was asked to speed up their activities in persuading underclassmen to join the A.S.M.E. Richard Cronin, president of the branch, warned all graduating members that the time was growing short and that they should fill out the application blanks for junior membership in the Society. The program consisted of a talk on metals specifications by Mr. Hambly of the Allis-Chalmers Manufacturing Company.

Election of officers to fill positions left vacant by the graduating seniors was held at the Feb. 19 meeting. The results were: Don Correll, president, Robert Della-Flora, vice-president; John E. Schoen, member A.S.M.E., honorary chairman; John W. Crim, publicity chairman; Ormond Henning, Earl W. Miller, and Les Wise, membership committee; Gordon Hurlbert and Raymond Metcher, board of governors.

University of Maryland Branch

The first meeting of the spring semester was held on Feb. 19 when a lecture was given by Dr. Philip Thomas of the Westinghouse Research Laboratories, entitled "Adventures in Electricity." Dr. Thomas has given this lecture in the leading institutions of the country, and it is considered one of the most outstanding electrical demonstrations ever offered to the public. Since 1911 Dr. Thomas has been doing research work with the Westinghouse Electric Corporation, and has participated in the research and development of electronic and light-sensitive devices of all kinds, including many applications of photoelectric cells. Recently he has had a weekly radio program entitled "Adventures in Research." Included in the demonstration were high-frequency radiation phenomena, vortex effects, resonant circuits, and voice transmission. One hundred and fifty members and visitors were present.

University of Nebraska Branch

The first meeting of the new semester, on Feb. 27 in Richards Laboratory, was a mechanical engineers' smoker, to which all mechanical engineers were invited. The speaker, J. K. Ludwickson, was introduced by Shig. Nakanishi, chairman. Mr. Ludwickson gave a talk on the work of graduate engineers, and intense interest was shown in the results of a questionnaire recently sent to engineering graduates of Nebraska. A showing of three films followed, among them a comic strip. LeRoy Foster was nominated as chairman for the forthcoming Engineers' Week and Irwin Cone for vice-chairman. Of the 33 present, 3 were newly returned former members, and 9 have just become new members.

New York University Branch

On Feb. 6 in Lawrence House a technicolor sound film was shown entitled "Turret Lathes." This film, produced by the Gisholt Company, illustrated the many useful applications of turret lathes to manufacturing processes. On some of the more complicated setups, three to four cuts were taken simultaneously in the turret lathes.

The members met at Trommer's Brewery on Feb. 9 and were welcomed by Mr. Reichl, chief engineer, who introduced Mr. Wyland, assistant chief engineer. Mr. Wyland conducted the members through the plant on a two-hour tour, which included all the im-

STUDENT BRANCH OF THE UNIVERSITY OF WISCONSIN

(*Front row, left to right:* T. R. Moyle, A. P. Kowalik, A. J. Schmitt, M. S. Smith, L. A. Wilson, P. S. Myers, G. E. Hlavka, J. H. Thuermann, T. C. Brugger. *Middle row, left to right:* G. A. Holloway, F. A. Dobbratz, J. M. Teskoski, D. E. Frank, J. D. Woodburn, F. R. Walker, O. K. Hunsaker, H. C. Adler. *Top row, left to right:* I. Chorlin, R. H. Lang, R. L. Heinrich, T. M. Amlie, G. W. Bailey, J. E. Hinkley, P. E. Tausche, D. L. Kerr, R. H. Laughlin, E. G. Brender.)

portant steps in the process of making beer. He pointed out especially all the equipment and processes of interest to mechanical engineers. The storing of carbon dioxide, the filtration of beer for yeast particles, the yeast presses and the bottling process were of great interest.

North Dakota Agricultural College Branch

The first meeting of the branch in two years was held on Feb. 4 at the college. It was a reorganization meeting and several of the former members who had returned to college after serving with the Armed Forces, were present and spoke on the advantages of membership in the A.S.M.E. and of the organization as it was in the college in former years. Election of officers was held and plans laid for an active membership.

Northeastern University Branch

On Feb. 14 in Richards Hall Frederick P. Hunsaker was the guest speaker. His subject was "Plastics for the Future," and in his talk Mr. Hunsaker remarked that there will be a great deal of competition from low-weight metals such as aluminum and magnesium, but that the plastics industry will attempt to meet such competition by expanding its production, with the drop in prices that usually accompanies expanded production facilities. He said that of the five types of plastics the synthetic is the most important, but only in the filled thermosetting form. He demonstrated the forming of plastics in an interesting visual experiment.

Northwestern University Branch

The second meeting of the winter semester was held on Feb. 1 in the Technological Institute Building. After a short business meeting, Professor Wyly of the civil-engineering department, Northwestern University, gave an illustrated lecture, the first portion of which was devoted to engineering problems he had encountered in bridge design and construction. The second portion was concerned with the 60,000-pound fatigue-testing machine recently completed in the materials-testing laboratory of the civil-engineering department. Fundamentals of vibrations and fatigue which pertained to the machine and its operation were reviewed. After the lecture, members and guests went to the laboratory to examine the fatigue-testing machine in operation. Professor Wyly explained the operation and use of the machine, a great part of the construction of which was under his supervision. He then answered questions about the machine.

Pennsylvania State Branch

A small reorganization meeting was held on Jan. 29 in the Armory, in preparation for a larger meeting which will be open to the public and will be a call for new members. Temporary officers were elected until the end of the semester for the purpose of carrying on the campaign for new members. These were: Marvin Breslaw, chairman; John Chiquoine, vice-chairman; Mary Field, secretary, and Donald Clark, treasurer.

Queen's University Branch

A general meeting was held on Feb. 21 in Fleming Hall. President John Soden called the meeting to order and introduced the speaker, Prof. H. S. Pollock of the electrical-engineering department. Professor Pollock spoke on "Electronics and Their Applications to Industry." He discussed several interesting applications of the photoelectric cell, variable-capacity and variable-inductance circuits, the piezoelectric effect of crystals, and induction heating. Among the many applications were the measurement of pressures, deflections, torques, hardness of steels, vibration, and other uses in the mechanical field.

Rice Institute Branch

A meeting was held on Jan. 11, at which time new officers were elected as follows: C. Leo Raver, chairman; Emerson E. Cook, vice-chairman; L. Wallace Meier, secretary, and Raymond M. VanWhy, treasurer. The treasurer gave his report, and plans for an inspection trip discussed.

University of Rochester Branch

Chairman Jack Krosse presided at the regular business meeting on Feb. 5 in the Rush Rhees Library. Dr. Falls expressed his appreciation of the work done by the retiring officers during the past semester. An election for the March to July term resulted as follows: William Harison, chairman; John Mount, vice-chairman; Ernest L. Dunning, secretary; Robert D. Hughes, treasurer.

Tufts College Branch

On Jan. 16 Prof. David A. Fisher, junior member A.S.M.E., and Dean Edgar MacNaughton, member A.S.M.E., escorted a group of senior engineers of the branch to the district meeting at Northeastern University, where a very interesting talk was given by Mr. Jewitt, vice-president, American Research Corporation, on high vacuum and its application to industry.

An old-fashioned sleigh ride in the country was enjoyed by the members on Jan. 26. After an hour and a half of brisk sleighing, the group visited a roadhouse in the country for dancing; then a quick ride back to Beverly where the Boston train was waiting. Everyone agreed that it was a most unusual and successful meeting.

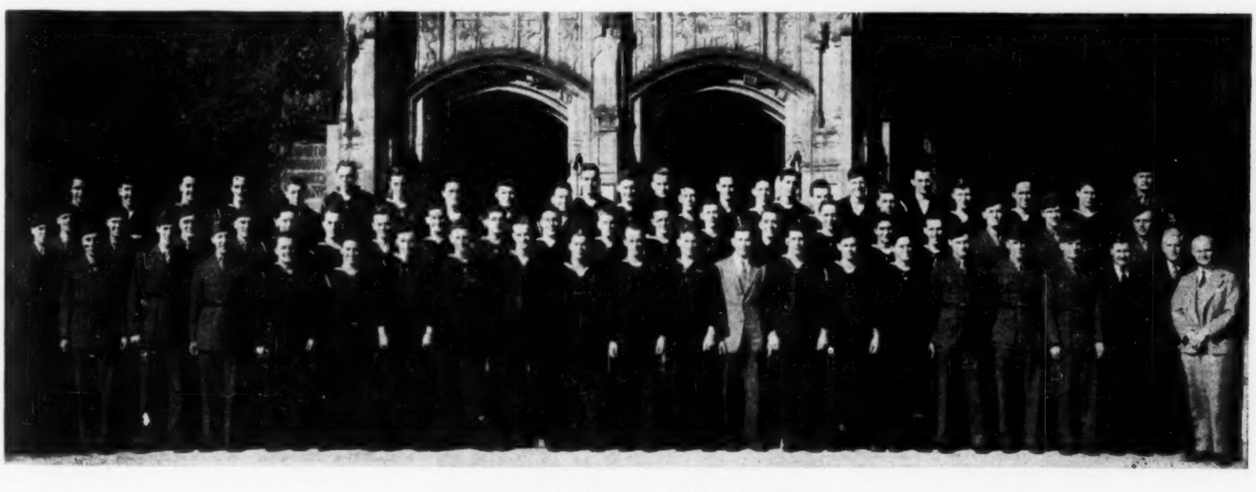
On Jan. 28 a visit was made to the "L" Street Station of the Boston-Edison Power Company. Acting as guides, engineers in the employ of the power company showed the equipment which goes to make up a modern power station. Prof. David Fisher, who was in charge of the group, showed all the detailed equipment which had been used on a small scale in the college laboratory, and illustrated how the theoretical calculations in class tied in with the actual plant operation for a large metropolis.

Worcester Polytechnic Institute Branch

A short meeting was held on Jan. 24 in Higgins Laboratory for the purpose of electing new officers for the coming school year. Those elected were: Joseph P. Manna, president; George Button, vice-president; Allen Breed, secretary-treasurer.

Yale University Branch

A series of talks sponsored by the branch, and directed toward helping the graduating engineers in choosing their fields of work following graduation, were conducted at the University during January and February. The



STUDENT BRANCH OF YALE UNIVERSITY

series consisted of a total of five lectures as follows: "Engineering Procurement," by W. A. Sredenschek, engineering general division, General Electric Company, Schenectady, N. Y.; "Positions in Research and Development," by John G. Lee, assistant director of research, United Aircraft Corporation, East Hartford, Conn.; "Industrial Engineering," by A. T. Wolf, Scovill Manufacturing Company, Waterbury, Conn.; "Design and Shop Practice," by David Smith, Waterbury Tool Company, Waterbury, Conn.; and "Engineering in the Power and Consulting Fields," by Howard Barton, Hamden, Conn. The last lecturer was connected with the Long Island Light and Power Company for some years, and is now working as a consultant engineer for various firms. The broad scope covered by these talks was effective in presenting to the engineers various applications of engineering in the industrial field.

A.S.M.E. Local Sections

Coming Meetings

Akron-Canton. April 25. Dinner 6:30 p.m.; meeting 8:00 p.m. at Y.W.C.A., Akron, Ohio. Subject: "Hard Plastics" by Henry M. Richardson, DeBell & Richardson, consulting engineers, Springfield, Mass.

Anthracite-Lehigh Valley. April 26. Penn-Stroud Hotel, Stroudsburg, Pa. at 8:00 p.m. Subject: "Materials and Construction, Centrifugal Boiler Feed Pumps." Speakers will be representatives of the various pump companies in the Section, and the meeting will be in the form of a round-table forum discussion.

Central Illinois. April 9. Peoria Country Club, Peoria, Ill. at 6:30 p.m., Annual Business Meeting and President's Night. Robert D. Yarnall, president A.S.M.E., will give a short address on "Engineering and Citizenship."

Chicago. April 3, 4, 5. Palmer House, Chicago, Ill. Midwest Power Conference, April 10. Evening meeting will be President's Night. D. Robert Yarnall, president A.S.M.E., will address the members on the subject of "Engineering and Citizenship."

Cincinnati. April 11. Schneider Foundation (Engineering Societies Building) at 8:00 p.m. Joint Meeting of Cincinnati Sections, A.S.M.E., A.I.E.E., and A.S.T.E. Subject: "Electrical Equipment for Machine Tools," by Tell Berna, general manager, National Machine Tool Builders' Association.

Cleveland. April 11. Dinner at 6:30 p.m.; meeting at 8:00 p.m. Hotel Cleveland. Subject: "Engineering and Citizenship" by D. Robert Yarnall, president A.S.M.E.

Detroit. April 16. Evening meeting (time and place to be determined). Subject: "Recent Work in Forging Research," by Dr. W. Trinks, project director, A.S.M.E. research committee on Forging of Shells and Bomb Bodies. Dr. Trinks is the A.S.M.E. Lecturer.

Metropolitan Section

April 11. 2:30 p.m. A.S.M.E. Woman's Auxiliary. Matinee Theatre Party, "Carousel."

April 17. 7:30 p.m. Auditorium.[1] A.S.M.E. Lecture by Dr. Lionel S. Marks, Fellow A.S.M.E. professor emeritus of mechanical engineering, Harvard University, Cambridge, Mass., on "Jet Propulsion and Rockets."

April 23. 7:30 p.m. Room 502.[1] Applied Mechanics Division meeting.

April 23 and 24. 7 p.m. Regional Administrative Committee meeting.

April 24. 7:30 p.m. Process Industries Division meeting. Inspection trip to Ruppert's Brewery, 1639 Third Avenue, New York, N. Y.

Milwaukee. April 17. Hotel Pfister (Fern Room), 8:00 p.m. Subject: "Society and Atomic Energy," by Dr. W. F. Libby, department of chemistry, University of Chicago, Chicago, Ill.

Philadelphia. April 2. University of Pennsylvania, Subject: "Automotive Postwar Applications of Diesel Engines," by Rex W Wadman, editor-publisher *Diesel Progress.*

[1] Engineering Societies Building, 29 West 39th St., New York, N Y.

April 7. Engineers' Club, Philadelphia, Pa., from 3:00 to 5:00 p.m. Reception in honor of President and Mrs. D. Robert Yarnall.

April 16. University of Pennsylvania. Subject: "Resin Adhesives for Woods," by Thomas D. Perry, and "Engineering Applications of Plexiglass," by Ralph E. Hess. Talks will be illustrated by slides and there will be an exhibit.

April 23. Engineers' Club. Joint meeting with The Society of Naval Architects and Marine Engineers honoring the centennial year of the birth of George Westinghouse.

Plainfield. April 17. Elks Club, Elizabeth, N. J., at 8:00 p.m. Subject: "Metal Spraying," by Harry Collins, Metallizing Engineering Company, Incorporated, and Dr. B. Goldberg, Schori Process Corporation.

Southern California. April 25. Subject: "Hypersorption," by Dr. Berg, research department, Union Oil Company of California.

April 27. Field trip through the Wilmington, Calif., refinery of Union Oil Company of California. Time: 1:00 p.m.

Engineering Societies Personnel Service, Inc.

These items are from information furnished by the Engineering Societies Personnel Service, Inc., which is under the joint management of the national societies of Civil, Electrical, Mechanical, and Mining and Metallurgical Engineers. This Service is available to members and is operated on a co-operative, nonprofit basis. In applying for positions advertised by the Service, the applicant agrees, if actually placed in a position through the Service as a result of an advertisement, to pay a placement fee in accordance with the rates as listed by the Service. These rates have been established in order to maintain an efficient, nonprofit personnel service and are available upon request. This also applies to registrants whose notices are placed in these columns. All replies should be addressed to the key numbers indicated and mailed to the New York office. When making application for a position include six cents in stamps for forwarding application to the employer and for returning when necessary. A weekly bulletin of engineering positions open is available to members of the co-operating societies at a subscription of $3 per quarter or $10 per annum, payable in advance.

New York	Boston, Mass.	Chicago	Detroit	San Francisco
8 West 40th St.	4 Park St.	211 West Wacker Drive	109 Farnsworth Ave.	57 Post Street

MEN AVAILABLE[1]

INDUSTRIAL ENGINEERING GRADUATE. Single, 30, Tau Beta Pi. Six years' varied administrative experience; 4 years steel mill; 2 years naval officer; desires position assistant to management or industrial engineering, Northeast. Me-21.

M.E. DEGREE STEVENS INSTITUTE OF TECHNOLOGY. Five years telephone maintenance, 10 years with a heavy industry, last 2 in charge of purchasing for one plant. Desires purchasing or production supervisory position. Me-22.

MECHANICAL ENGINEER. B.S. degree, 30, four years' experience testing, design and production of ordnance material. Desires responsible position with small but growing manufacturing or processing concern. Me-23.

[1] All men listed hold some form of A.S.M.E. membership.

GRADUATE MECHANICAL ENGINEER, 31, married, experienced in design of steam generators and in supervision, maintenance and operation of steam power plant, Lt. U.S.N.R. chief engineer, 15,000-ton ship. Middle West preferred. Me-24-2611-Chicago.

EXPERIENCED ENGINEER. B.S., M.E., Carnegie Institute of Technology, 36, ex-naval lieutenant. Excellent references, pleasant appearance and personality. Varied experience sales, production, management, and operations engineering. Can effectively handle sales or production problems for your company. Me-25.

GRADUATE MECHANICAL ENGINEER. Discharged naval officer; two years' experience in 100,000-hp steam plant. Experienced in personnel-machine shop, and maintenance work. Desires research and experimental work in mechanical-engineering lines. Me-26.

GRADUATE MECHANICAL ENGINEER. Cana-

dian, 24, three years' experience improving manufacturing methods-buying machine tools, and supervising work-simplification group. Small company preferred. U. S. or Canada. Me-27.

MECHANICAL ENGINEER. Graduate, married, 28; six years' experience commercially and as naval lieutenant (Bureau of Ships) in power-plant engineering, installation, supervision, and layout including all auxiliaries. Prefer East. Me-28.

MECHANICAL DEVELOPMENT ENGINEER. Single, 32, graduate; over 8 years in research and development of hydraulic and pneumatic control equipment, including 3 years with automatic-controls manufacturer, 4 years supervising hydraulics development group of large aircraft company. Available immediately. Prefer West Coast. Me-29-458-D-7-San Francisco.

MECHANICAL ENGINEER. University of Michigan, 1939, with 7 years' supervisory experience in inspection, quality control, and contacting subcontractors regarding quality and production, desires supervisory or sales-engineering position. Any location. M-30-Detroit.

POSITIONS AVAILABLE

PRODUCTION ENGINEERS. Over 40 preferred, mechanical or chemical, experienced in fundamental requirements of cement, tile, brick, and related ceramic industries to conceive and have made by local artisans and technicians, necessary equipment for small-scale production of these items as best suited for locally available raw materials and labor resources. $5325 year, plus maintenance and allowance for dependents. Minimum one year. China. W-6676.

SERVICE ENGINEER. Mechanical preferred, need not be graduate, with experience in pumps. Will supervise repair, replacement, and construction work in connection with water and sewage-treatment plants. Considerable traveling. Territory, Maine to North Carolina. Salary open. Headquarters, New York, N. Y. W-6685.

METHODS ENGINEER, 26–40, with at least 3 years' experience in time study and methods; preferably in process industry. Will be responsible for time and motion studies, standard specification sheets, engineering reports, laboratory tests; and for recommending design new equipment for more efficient production. $3120 year. Northern New Jersey. W-6695(a).

ENGINEERS. (a) Works manager, 35–50, preferably mechanical graduate, with experience in practical application of modern manufacturing methods, especially those that relate to job-lot production. Should be familiar with cold-pressing, stamping, drawing, plating, and polishing operations, preferably in nonferrous metals, for factory of 800 men. $7000–$8000 year. New England. (b) Plant manager, 35–45, mechanical graduate or equivalent, with several years' experience in fine cold-rolling and in fabrication of small metallic parts, especially those requiring close manufacturing controls; and experience in welding and strip milling. Will spend time in factory rather than in office. About $10,000 year. New York metropolitan area. W-6699.

CHIEF ENGINEER, 25–45, for leading gear and speed-reducer manufacturer. Should have some designing experience in connection with gears or other power-transmission machinery. Should also be equipped with some executive ability to head such an engineering department. Pennsylvania. W-6700.

REGIONAL SALES MANAGER for Eastern Seaboard area, to work through distributor on welding positions. Knowledge of welding desirable. Approximately $6000 year, on salary-plus-commission basis. Headquarters, New Jersey. W-6715.

PERSONNEL DIRECTOR with background in labor relations and in routine of handling personnel problems in office or field. Must be qualified to establish whole procedure necessary for inaugurating system and carrying out problems of labor relations. Salary open. New York, N. Y. W-6731.

REGIONAL PLANNING ENGINEER to head investigations, studies, and preparation of reports on long-range development of transmission and distribution facilities for large electric utility. Technical training, initiative or independent thinking essential, supplemented by previous responsible operating or engineering work. $5000 year. Pennsylvania. W-6742.

ENGINEERS, technical graduates or equivalent. (a) Works manager, over 35, with 15 years' industrial experience involving supervision, planning or tooling in aircraft industry and supervising 750 people. Approximately $10,200 year. (b) Project superintendent, over 30, with at least 10 years' experience involving aircraft-industry supervision of 250 people or over. Approximately $7200 year. (c) Production-control manager, over 30, with 10 years' industrial experience including supervision of at least 100 people and with shop experience; aircraft experience desirable. Approximately $7000 year. (d) Planning manager, over 28, with 8 years' industrial experience on planning, tooling, industrial engineering, or plant layout, especially in aircraft industry. Approximately $6000 year. California. W-6743.

CONSTRUCTION MECHANICAL ENGINEER. Should have experience in construction of small industrial building and be capable of laying out and installing mechanical machinery for chemical-process plant. Should have some knowledge of French. $8000–$10,000 year. Caribbean area. W-6755.

REFRIGERATION PLANT ENGINEER. Should be graduate, 30–40. Must thoroughly understand commercial-refrigeration equipment specifications and be able to make plant layouts and install equipment in field. $6000 year. New York, N. Y. W-6756.

SUPERINTENDENT of power plant, 30–35, preferably mechanical graduate, familiar with design and operations of small industrial steam-power plant to supervise plant operation including steam generation and distribution, electric power and light distribution, and water-treatment facilities. $4200–$5400 year. Tennessee. W-6767.

REPRESENTATIVE, 30–35, preferably with manufacturing and machinery sales experience. Must speak Portuguese or Spanish. Company pays moving expenses. About $4200 year. First 8 months will be spent in United States. Brazil. W-6785.

ASSISTANT OR ASSOCIATE PROFESSOR of industrial engineering with industrial managing experience and some experience in teaching. Man with graduate work preferred. Starting date, July 1, 1946. To $3600 for academic year with additional allowance for summer teaching. Chicago, Ill. R-3250-C.

Candidates for Membership and Transfer in the A.S.M.E.

THE application of each of the candidates listed below is to be voted on after April 25, 1946, provided no objection thereto is made before that date, and provided satisfactory replies have been received from the required number of references. Any member who has either comments or objections should write to the Secretary of The American Society of Mechanical Engineers immediately.

KEY TO ABBREVIATIONS

Re = Re-election; Rt = Reinstatement; Rt & T = Reinstatement and Transfer to Member.

NEW APPLICATIONS

For Fellow, Member, Associate or Junior

ADAMS, FRANK P., San Francisco, Calif.
AHRENDT, WILLIAM ROBERT (LIEUT.), Washington, D. C.
ALBERTI, JOHN, Seattle, Wash.
ARMSTRONG, R. M., West Chester, Pa.
ASPIN, FRANK, York, Pa.
BABER, JOHN E., Charlotte, N. C.
BAKER, SOL, East Cleveland, Ohio
BATES, B. J. (ENSIGN), Bronx, N. Y.
BELL, WILLIAM C., New Haven, Conn. (Rt)
BENNINGHOVEN, RHEIN, Kansas City, Mo.
BOHANNON, G. W., Chicago, Ill. (Rt & T)
BOLAND, WILLIAM H., Allentown, Pa. (Rt)
BOURLON, ALFRED, Mexico, D. F.
BOWDEN, GEORGE E., Corning, N. Y.
BRASS, WILLIAM C., Douglaston, N. Y.
BROWN, LINSLY G., Jamestown, N. Y.
BROZ, ALBERT F., Los Angeles, Calif.
BRYDIA, E. M., York, Pa.
CADMUS, THOMAS W., Columbus, Ohio (Rt & T)
CARDANI, CHARLES PETER (LIEUT. COMDR.), Boston, Mass.
CASSELMAN, THEODORE E., JR., Waban, Mass. (Rt & T)
CASTLE, ROBERT L., Hollywood, Ill.
CHAPMAN, J. B., Detroit, Mich. (Rt & T)
COHEN, PAUL, Great Neck, N. Y.
COLLINS, SAMUEL C., Cambridge, Mass.
CRABBS, W. J., Wilmington, N. C.
CREAN, THOMAS A., South Nyack, N. Y.

CUNNINGHAM, ROBERT T. (COL.), Aberdeen Proving Ground, Md. (Rt & T)
DAY, H. S., Kansas City, Mo.
duFRESNE, WILLIAM E., Elmhurst, N. Y.
DUMOND, T. C., New Rochelle, N. Y.
DUNFORD, G. S., Rochester, Ill. (Rt & T)
FAIRFIELD, W. M., Los Angeles, Calif. (Rt & T)
FALLET, P., New York, N. Y.
FANT, J. E., Spartanburg, S. C.
FECHT, JOHN B., JR., Charleston, W. Va.
FITCH, W. CHESTER, Bozeman, Mont.
FORMAN, FRANKLIN WOLD, Angola, Ind.
FRANKLIN, J. N., Corner Brook, Newfoundland
FRANKS, THEODORE W., Chicago, Ill.
FUSCO, MICHAEL A., Brooklyn, N. Y.
GAGLIARDI, E. J., Buenos Aires, Argentina
GARIN, P. V., San Francisco, Calif.
GARTNER, NOLAN P., Watts Bar Dam, Tenn.
GEAUQUE, ROBERT E., Washington, D. C. (Re)
GEIGER, ALBERT WILLIAM, Willow Grove, Pa.
GEORGE, CHARLES, Bronx, N. Y.
GOODWIN, GEORGE P., New York, N. Y.
GOODYEAR, NELSON, New York, N. Y.
GOTSCH, ERWIN C., Chicago, Ill. (Rt)
GREEN, VERNON L., Milwaukee, Wis.
GRIFFITH, LEONARD F., Oak Park, Ill.
HAAS, RAYMOND A., Philadelphia, Pa.
HALL, VIRGIL G., Savannah, Ga.
HALLAMAN, J. C., Palo Alto, Calif.
HAUSER, GILBERT B., New Kensington, Pa.
HEINTZ, A. PRESTON (MAJOR), Newton, Mass.
HERZOG, WILLIAM F., JR., Cranford, N. J.
HEYE, B. F., Corpus Christi, Texas
HINDS, ZACK C., Kenmore, N. Y.
HITESHUE, RAYMOND WILLIAM, Pittsburgh, Pa.
HOLLAR, PHILIP A., Chicago, Ill.
HOLSTEIN, JOHN H., Chicago, Ill.
HOOVER, M. R., Rodeo, Calif.
HORIGAN, DANIEL L., East Orange, N. J.
HUDYMA, STANLEY, Brooklyn, N. Y.
HUNG, CHAN BING, Kowloon, Hong Kong, China (Re)
HUNT, HARMON S., Douglas Manor, N. Y. (Rt & T)
HUNTER, D. D., Montreal, Quebec, Can.
HUNTER, J. A., JR., Hales Corners, Wis.
HUTZELMAN, ROBERT W., Buffalo, N. Y.
JOHNSON, FRITHIOF V., Scotia, N. Y.
JOHNSON, ROBERT L., Melrose, Mass.
KETTLE, KENATH A., Charleston, W. Va.
KLEIN, GEORGE F., Kansas City, Mo. (Rt)
KUPKA, JOHN J., Gladstone, N. J.
LAMMERS, HERBERT B., Cincinnati, Ohio
LAMMINEN, ARTHUR J., Detroit, Mich.
LAMPTON, PRESTON W., Wellesley, Mass. (Re)
LAWSER, JOHN J., Philadelphia, Pa.
LAWSON, A. B., Catonsville, Md.
LEAVITT, ERNEST E., Medford, Mass. (Rt & T)
LOFTIS, JOHN DAVID, JR., Wilmington, N. C.
LOTT, H. E., Houston, Texas
LOVE, COLIN WILSON, Renfrewshire, Scotland
LUND, BART, Riverside, Ill.
MACALUSO, HENRY, Clifton, N. J.
MADERO, V. CANALIZO, Mexico, D. F.
MARSH, JOHN W., Alexandria, Va. (Rt)
MARTIN, JOHN D., Cascade Locks, Ore.
MARVIN, STANLEY, Oakland, Calif.
MAY, ELDON M., Bremerton, Wash.
McCLURE, ARTHUR F., Kansas City, Mo.
McCORD, W. E., St. Louis, Mo.
McKANE, R. F., Chicago, Ill.
McPHERSON, JOHN A., JR., Greenville, S. C.
MEYER, ARNOLD, Pewaukee, Wis.
MEYER, DANIEL W., Michigan City, Ind.
MILLER, EARLE C., Worcester, Mass.
MILLER, EDWARD D., Portland, Ore.
MILLER, HARRY P., JR., Brooklyn, N. Y. (Rt & T)
MORRIS, JOHN MARSHALL, Louisville, Ky.
MORRIS, L. DONALD, Williamsville, N. Y.
MOSES, EDWIN P., White Plains, N. Y.
MYERS, N. F., Short Hills, N. J.
NEALE, ABAS B., Red Bank, N. J.
NEUGEBAUER, GEORGE H., Brooklyn, N. Y.
NICKLE, H. D., New York, N. Y. (Rt & T)
NORMAN, A. W., Halifax, Nova Scotia
NORTON, JAMES R., Chicago, Ill.
OKMEN, FARUK, Ankara, Turkey
OLSEN, NORMAN T., Chicago, Ill.
ORLAND, FRANK A., Dayton, Ohio
PALM, FRANK J., St. Paul, Minn.
PAULSEN, E. LESLIE, Jamaica, N. Y.
PIATT, DONALD R., Endicott, N. Y.
PRATHER, JOHN B., Yonkers, N. Y.
PRATT, P. P., New York, N. Y. (Rt)
PURCELL, MARION E., Kansas City, Mo.
RAMSEY, WEBSTER K., Worcester, Mass. (Rt)
RANDALL, MAX, Bronx, N. Y.
RAO, P. V. C., Bijapur, India
RHODES, ARTHUR WINFRED, South Charleston, W. Va.
ROGERS, HARRY S., Brooklyn, N. Y.
ROSS, FRANK E., JR., Chicago, Ill.
ROUDEBUSH, SAM I., Cuyahoga Falls, Ohio
SAUNDERS, GORDON L., Charleroi, Pa.
SCHAEFER, FREDERICK F., Newark, N. J.
SICH, EDWARD, Cleveland, Ohio
SIVERT, HENRY C., JR., Kingsport, Tenn.
STEVENSON, WM. SHERMAN, New York, N. Y.
STOUFFER, S. WILLIAM, Pittsburgh, Pa.
SULLIVAN, CLAYTON L., Seattle, Wash.
TANGARD, EINAR, Brooklyn, N. Y.
TRAVIS, HAROLD, Hasbrouck Heights, N. J.
VINCENT, THOMAS C., New York, N. Y.
WAINA, WILLIAM F., Pittsburgh, Pa.
WALTON, HENRY, Brooklyn, N. Y.
WHARTON, ARMISTEAD, Detroit, Mich.
WILLIAMSON, DONALD E., Allen Park, Mich.
WILSON, R. B., Springfield, Mass.
WYKES, STANLEY ALLEN, Blacksburg, Va.
YANDRE, THOMAS E., Orlando, Fla.

CHANGE OF GRADING

Transfer to Fellow

O'BRIEN, E. W., Atlanta, Ga.

Transfer to Member

BOWES, THOMAS D., Cleveland, Ohio
DONAHUE, EDWARD B. (LIEUT. COMDR.), Evanston, Ill.
DYKE, THEODORE A., New York, N. Y.
ENZINGER, LEONHARD, Brooklyn, N. Y.
HUNTER, JOHN A., JR., Pittsburgh, Pa.
JENNINGS, J. T., JR., Kansas City, Mo.
KEENER, H. JAMES, Newark, N. J.
KOFFMANN, E., Pittsburgh, Pa.
KREINER, A. J., Wickliffe, Ohio
MACGOWAN, GEORGE F., Schenectady, N. Y.
MAJORS, HARRY, JR., Cambridge, Mass.
MATER, MILTON H., Corvallis, Ore.
MCANULTY, JAMES C., Evanston, Ill.
MCMANMON, JOSEPH C., Bay City, Mich.
NICKEL, ALFRED A., San Francisco, Calif.
PICK, WILLIAM J., Valley Stream, N. Y.
ROGERS, EDWARD LOUIS, York, Pa.
TALMAGE, RALPH HOUSTON (COL.), Redwood City, Calif.
WEDGE, D. E., Flint, Mich.

Transfers from Student Member to Junior 115

Necrology

THE deaths of the following members have recently been reported to headquarters:

BLOSS, LEONARD C. M., February 10, 1946
BROWN, CARL G., May 18, 1945
BROWN, JOHN J., February 15, 1946
BOYCE, WILLIAM J., JR., June 12, 1943*
CHIFFELLE, FRANCIS A., January 6, 1946
DEWOLF, ROGER D., February 2, 1946
DUNLOP, WILLIAM C., December 7, 1945
HAMMOND, EDGAR S., December 20, 1945
HEYE, OTTO, May 31, 1944*
HUGHES, RAYMOND M., February 14, 1944
KENDALL, THEODORE R., February 4, 1946
POLGLAZE, RICHARD A., November 3, 1945
SIBLEY, BARRETT E., February 13, 1946
STEWART, WARREN D., January 28, 1946

* Died in line of duty.

A.S.M.E. Transactions for March, 1946

THE March, 1946, issue of the Transactions of the A.S.M.E., which is the *Journal of Applied Mechanics*, contains:

TECHNICAL PAPERS

- The Theory of Plasticity—An Outline of Work Done in Russia, by W. W. Sokolovsky
- A Velocity-Modified Temperature for the Plastic Flow of Metals, by C. W. MacGregor and J. C. Fisher
- Design of Crankpins for Locomotives, by O. J. Horger and W. I. Cantley
- On Dimensional Analysis and the Presentation of Data in Fluid-Flow Problems, by E. R. Van Driest
- A Uniform Method for Determining Angular Accelerations in Mechanisms, by L. R. Koenig
- Stresses in Rotating Disks at High Temperatures, by A. S. Thompson
- Nonlinear Theory of Elasticity With Small Deformations, by E. Sternberg
- Compressible Flows Obtainable From Two-Dimensional Flows Through the Addition of a Constant Normal Velocity, by H. Poritsky

DISCUSSION

- On previously published papers by Leon Beskin; E. A. Davis; A. F. Donovan, Martin Goland, and J. N. Goodier; and D. C. Drucker and H. Tachau

BOOK REVIEWS